ZOOLOGICA.

Original-Abhandlungen

aus

dem Gesamtgebiete der Zoologie.

Herausgegeben

von

Professor Dr. Carl Chun in Leipzig.

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Fünfte Lieferung.

Inhalt:

Edward Phelps Allis, jr., The Cranial Anatomy of the Mail-cheeked Fishes. Lfg. 3.

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Herbst 1909

ZOOLOGICA

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Periodica und Werke
der letzten Jahre

E. Schweizerbart'sche Verlagsbuchhandlung
Nägele & Dr. Sproesser, Stuttgart

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Wie alljährlich, so möchten wir uns auch jetzt wieder erlauben, Ihre Aufmerksamkeit auf die in unserem Verlage erscheinende

Zoologica

Originalabhandlungen aus dem Gesamtgebiete der Zoologie

herausgegeben von

Prof. Dr. C. Chun in Leipzig

zu lenken und dafür Ihr gütiges Interesse zu erbitten.

Wie Sie aus dem beigefügten Verzeichnis ersehen wollen, sind auch im verflossenen Jahre wieder mehrere hervorragende Monographien der „Zoologica" angereiht worden, resp. befinden sich z. Zt. in Vorbereitung. Wir würden es daher dankbar begrüßen, wenn auch Sie sich immer mehr von der Wichtigkeit der „Zoologica" und der in ihr erscheinenden tiefgründigen Monographien als unentbehrliches Nachschlagewerk bei Ihren Arbeiten überzeugen wollten und sich daraufhin zu einem Abonnement auf diese hervorragende Zeitschrift oder auch zur Anschaffung der einen oder anderen Abhandlung entschließen könnten.

*Für diesen Fall erlauben wir uns, Sie noch ergebenst darauf hinzuweisen, daß wir bereit sind, die „Zoologica" bei Abnahme der ganzen Serie von Heft 1—53, 54[1], 55—57 statt Mk. 2752.— zu Mk. **1800.**— abzugeben, sowie auch auf eine größere Anzahl Hefte erheblichen Preisnachlaß zu gewähren, um neu hinzukommenden Abonnenten die Ergänzung der ganzen Serie oder auch die Anschaffung älterer Hefte nach Möglichkeit zu erleichtern.*

Indem wir noch die weiter aufgeführten Werke unseres Verlages Ihrer geneigten Beachtung empfohlen halten, zeichnen wir

Hochachtungsvoll ergebenst

Stuttgart,
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Soeben erschien in unserem Verlage:

LEHRBUCH
der Vergleichenden Anatomie der Wirbeltiere

von

Dr. W. Schimkewitsch

ord. Professor der Zoologie und vergleichenden Anatomie, Direktor des Zoologischen Instituts der Universität St. Petersburg

Mit Genehmigung und Unterstützung des Verfassers ins Deutsche übertragen und bearbeitet von

Dr. H. N. Maier und **B. W. Sukatschoff**

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Der bedeutende Ruf, den der Verfasser als vergleichender Anatom überall in Fachkreisen geniesst und die besonderen Vorzüge seines Lehrbuches gegenüber andern ähnlichen Publikationen veranlassten Übersetzer und Verleger, von dem obigen Werke eine deutsche Ausgabe zu veranstalten. Welchen Anklang die neuartige Behandlung des Stoffes durch Professor Schimkewitsch gefunden hat, möge aus der Tatsache hervorgehen, dass nach kurzer Zeit von der russischen Ausgabe eine zweite Auflage in Angriff genommen werden musste. Am besten aber werden die Ziele, die der Verfasser mit seinem Werke verfolgt hat, aus dem Vorwort ersehen werden können, das wir umstehend auszugsweise wiedergeben. Ganz besonders möchten wir noch darauf hinweisen, dass dem Buche **zum ersten Male farbige Abbildungen** beigegeben sind, wodurch das Verständnis der Materie wesentlich gefördert werden dürfte. Trotz der reichen Illustrierung und der schönen äusseren Ausstattung haben wir den Preis für das Werk sehr niedrig angesetzt, um die Anschaffung desselben nach Möglichkeit zu erleichtern. Wir bitten daher das Buch freundlich aufnehmen und speziell die Studierenden auf dasselbe hinweisen zu wollen.

Das Werk wird von jeder Buchhandlung gerne zur Einsichtnahme zur Verfügung gestellt.

Hochachtungsvoll

E. Schweizerbart'sche Verlagsbuchhandlung
Nägele & Dr. Sproesser

STUTTGART, im Dezember 1909.

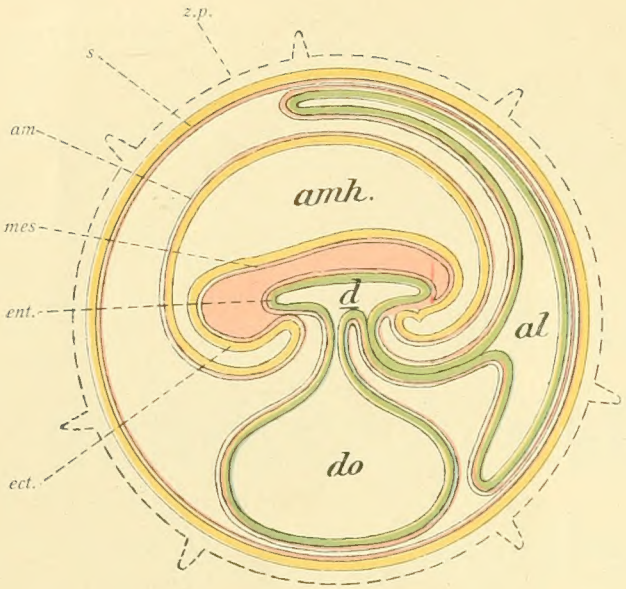


Fig. 47.
Embryonalhüllen eines **Säugetieres.** *al* — Allantois, *am* — Amnion, *amh.* — Amnionhöhle, *d* — Darmhöhle, *do* — Dottersack, *ect* — Ectoderm, *ent* — Entoderm, *mes* — Mesoderm, *s* — Serosa, *z.p.* — Zona pellucida (Prochorion). Derivate des Ectoderm braun, Mesoderm rot, Entoderm grün. [Nach TURNER.]

Aus dem Vorwort des Verfassers:

Bei Abfassung des vorliegenden Lehrbuchs habe ich mir die Aufgabe gestellt, den Studierenden einen kurzen, aber doch möglichst vollständigen Leitfaden für das vergleichend-anatomische Studium der Wirbeltiere zu geben.

In der Annahme, dass die Überladung der Lehrbücher durch secundäre Details manchmal nicht nur einen überflüssigen Ballast bildet, sondern das Studium ausserordentlich erschwert, da der Anfänger meist nicht in der Lage ist, das Wesentliche von dem Unwesentlichen zu unterscheiden, habe ich mich bemüht, diese Überladung zu vermeiden und die Hauptzüge in den Vordergrund zu stellen. Deshalb geht der speziellen sachlichen Beschreibung der einzelnen Organsysteme oder ihrer Teile eine kurze anatomisch-embryologische Übersicht voraus, in welcher ein ganz allgemeines Bild für das betreffende System oder seine Teile entworfen wird; zugleich soll ein theoretischer Standpunkt gegenüber dem Behandelten gewonnen werden. Es muss daher öfter in der ausführlichen Behandlung manches von dem wiederholt werden, was in der allgemeinen Übersicht schon erwähnt war. Diese Wiederholung bezieht sich aber nur auf die Hauptzüge, deren nochmalige Erwähnung ganz nützlich ist.

Von dem Gedanken ausgehend, dass das ausführlichere Studium irgend eines bestimmten Organsystems in didaktischer Hinsicht von grosser Bedeutung sein kann, halte ich mich etwas länger bei der Vergleichenden Osteologie auf, um so mehr, als die Bekanntschaft mit dieser Abteilung der Vergleichenden Anatomie am leichtesten durch das praktische Studium der Skelette in natura begründet werden kann.

Ich glaube, dass die theoretische Beleuchtung nicht nur das Studium erleichtert, sondern sie allein das Verständnis für die zu studierenden Tatsachen und deren Bedeutung ermöglicht. Deshalb wurde nirgends von dieser Behandlungsweise abgewichen, da ich es für besser halte, theoretische Betrachtungen einzuflechten, selbst wenn diese noch nicht ganz vollständig sind.

Bezüglich der Art der Behandlung konnte ich zwei Wege einschlagen. Den einen Weg zeigen die Lehrbücher von GEGENBAUR und von WIEDERSHEIM, welche bei der Beschreibung die Organsysteme manchmal sehr in ihre Bestandteile zerlegen und die Beschreibung des einen oder anderen Organes bei allen Gruppen der Wirbeltiere in aufsteigender Reihenfolge geben. Bei einer derartigen Behandlung treten die genetischen Beziehungen und die allmähliche Komplizierung eines Organs mit allergrösster Deutlichkeit hervor, dafür aber geht die anatomische Physiognomie der einzelnen Gruppen vollständig verloren. Letzteres wird dagegen sehr gut auf dem zweiten Wege erreicht, dem HUXLEY und in der neuesten Zeit PARKER und HASWELL folgten, die eigentlich eine anatomische Beschreibung einzelner Gruppen geben. Bei dieser zweiten Behandlungsweise tritt die ersterwähnte Seite vollständig in den Hintergrund und statt eines Lehrbuches der Vergleichenden Anatomie erhält man ein Lehrbuch der Zoologie auf vergleichend-anatomischer Grundlage. Dagegen kann man natürlich einwenden, dass die Charakteristik der Gruppen nicht die Aufgabe der Vergleichenden Anatomie bildet. Vom theoretischen Standpunkte aus kann man dem nur zustimmen, in der Praxis aber muss man mit der Tatsache rechnen, dass nicht selten bei dem Universitätsunterricht die Kenntnis der Wirbeltiere hauptsächlich nur auf einem vergleichend-anatomischen Studium derselben beruht, als dem wichtigsten und reichsten

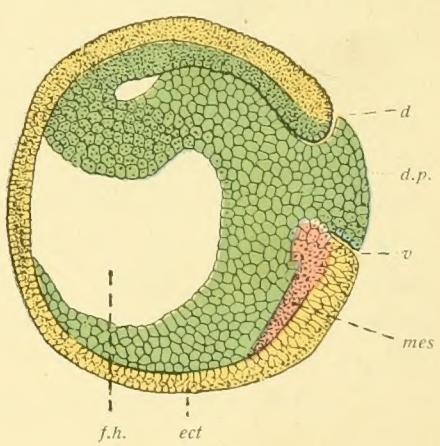
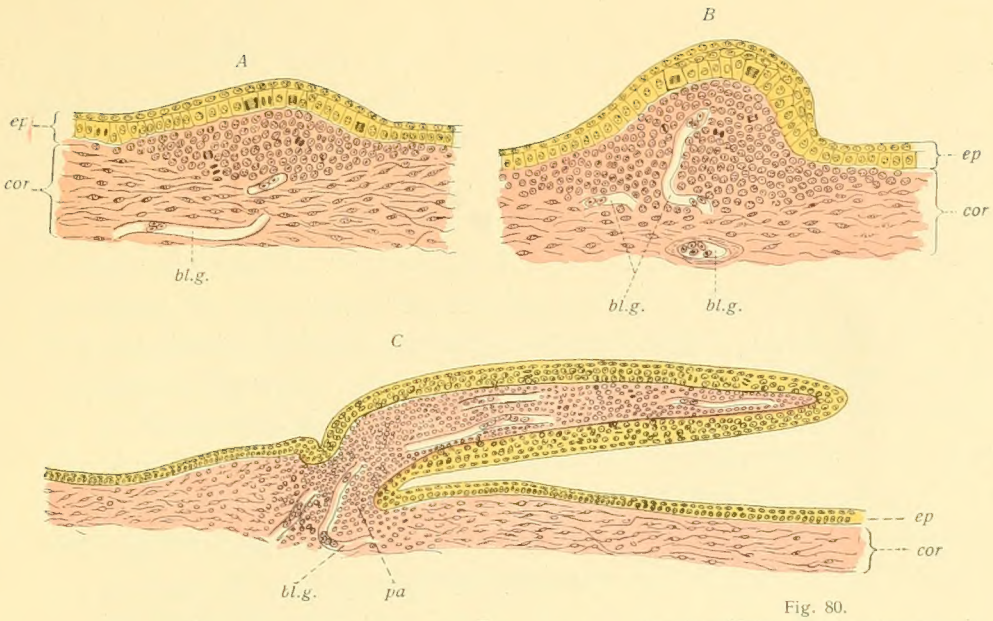


Fig. 34.
Rana. Sagittalschnitt durch die Gastrula: *d* — Dorsalrand des Blastoporus, *d.p.* — Dotterpfropf, *ect* — Ectoderm, *f.h.* — Furchungshöhle, *mes* — Mesoderm, *v* Ventralrand des Blastoporus. Die Ränder des Blastoporus umgrenzen den Dotterpfropf. Oben der sich zur Gastralhöhle erweiternde Gastralspalt. Ectoderm braun, Mesoderm rot, Entoderm grün. [Nach O. HERTWIG.]



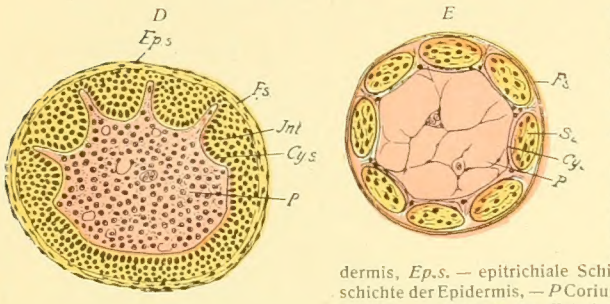


Fig. 80.

Gallus *(Huhn)*. Federentwicklung: *A* — erste Anlage der Feder im Längsschnitt, *B* — etwas weiter entwickelte Anlage im Längsschnitt, *C* — noch weiteres Stadium im Längsschnitt. *bl.g.* — Blutgefässe, *cor* — Corium, *ep* — Epidermis, *pa* — Coriumpapille. [Orig.] *D* — schiefgeführter Querschnitt durch eine der Fig. C entsprechende Anlage. *E* — Querschnitt durch den oberen Teil einer entwickelten Anlage vor dem Ausschlüpfen, mit schon ausgebildeten Strahlen; *Cy.s.* — Cylindrische Schicht der Epidermis, *Ep.s.* — epitrichiale Schicht, *Fs* — Federscheide, *Jnt* — Zwischenschichte der Epidermis, — *P* Coriumpapille (Pulpa), *S* — Strahlen der Embryonaldune. — Derivate des Ectoderm braun, Mesoderm rot. [Nach DAVIES.]

hinsichtlich seiner Ergebnisse. Deshalb darf meines Erachtens ein Lehrbuch der Vergleichenden Anatomie das zweite Ziel, nämlich dem Studierenden auch eine gewisse Vorstellung von der anatomischen Physiognomie der einzelnen Gruppen zu geben, nicht ganz ausser acht lassen, um so mehr, als bei einer zu weit gehenden Einteilung der Organsysteme in der Beschreibung manchmal die Einzelheiten das Ganze verdecken.

Mit Rücksicht hierauf wählte ich den Mittelweg, und zwar indem ich eine ausführlichere vergleichende Beschreibung einzelner Systeme und deren Teile gebe, bemühe ich mich, dieselben nicht allzusehr zu zerlegen. So werden z. B. alle Teile des Integumentes nach einzelnen Klassen, das Visceralskelett des Schädels mit dem Cranialskelett, die Rippen mit der Wirbelsäule, das innere Ohr mit dem mittleren und dem äusseren usw. beschrieben.

Ferner gehen der vergleichend-anatomischen Beschreibung zwei weitere Kapitel voran. Zuerst gebe ich eine kurze systematische Übersicht der Wirbeltiere mit Aufzählung hauptsächlich derjenigen Vertreter, welche in dem Texte erwähnt sind. Diese Behandlungsweise wurde schon von GEGENBAUR in einer etwas anderen Form in seinem alten Lehrbuche angewendet und ich finde sie vom praktischen Standpunkte aus sehr nützlich. Sodann folgt eine Beschreibung der ersten Entwicklungsstadien der Wirbeltiere, die für das Verständnis der in den nachfolgenden Kapiteln zu behandelnden Organogenie unentbehrlich ist. Schließlich wurde dem Beispiele der letzten Auflagen der „Vergleichenden Anatomie“ von WIEDERSHEIM folgend, das Kapitel über die Beziehung zwischen Eltern und Nachkommenschaft eingefügt, diese Frage aber noch ausführlicher als bei WIEDERSHEIM behandelt. Da die Viviparität (das Lebendiggebären) und die damit verbundene Entwicklung der Embryonalhüllen nur einen speziellen Fall der Brutpflege bilden, so mußte in diesem Kapitel auch die biologische Seite der Frage, zu welcher jene Erscheinung gehört, berührt werden.

Bezüglich der Auswahl der Abbildungen muß ich folgendes bemerken: Die neueren Arbeiten geben zwar ein reiches Material an Wiedergaben von Schnitten, sind jedoch sehr arm an Abbildungen, welche ein Organ als Ganzes und den Zusammenhang der Organe darstellen; solche Abbildungen sind aber gerade dank ihrer Übersichtlichkeit und Anschaulichkeit für Unterrichtszwecke die geeignetsten. Natürlich kann man dasselbe Ziel erreichen, wenn man Abbildungen einer ganzen Serie oder eigene Schemata gibt; im ersteren Fall erhöhen sich die Kosten der Auflage ausserordentlich, der zweite Weg ist aber für den Verfasser eines Lehrbuches unangenehm, wenn der Autor der Originalabhandlung selbst ihn zu begehen für nicht möglich hält.

Die Vergleichende Anatomie ist in der Hauptsache eine ideelle und bis zu einem gewissen Grade sogar eine philosophische Disziplin. Ich würde mich glücklich fühlen, wenn diese Ansicht in dem Leser durch das Studium meines Lehrbuches nicht zerstört, sondern befestigt würde.

Bitte wenden!

Aus dem Vorwort der Übersetzer:

Die Vorzüge, welche das SCHIMKEWITSCH'sche „Lehrbuch der Vergleichenden Anatomie der Wirbeltiere" vor anderen ähnlichen Lehrbüchern besitzt und welche im Vorwort des Verfassers näher erläutert sind, haben uns dazu bestimmt, dieses Werk ins Deutsche zu übersetzen. Unsere Beteiligung an der Neubearbeitung der russischen Auflage beschränkte sich unter Anleitung des Verfassers neben einigen Abänderungen am Texte hauptsächlich auf die Beschaffung von neuen, vielfach farbigen Abbildungen aus Originalabhandlungen und auf die Herstellung von Zeichnungen nach natürlichen Objekten und Präparaten (meist aus der Sammlung des Zoologischen Instituts der Universität Tübingen). Unser Bestreben, möglichst alle Abbildungen aus dem Gebiete der Entwicklungsgeschichte und des Blutkreislaufes, sowie bei Schnitten und schematischen Figuren in einheitlicher Weise farbig darzustellen, soll den Lernenden das Verständnis der Abbildungen erleichtern, ein Hilfsmittel, von dem ja bei den Vorlesungen an den Hochschulen schon länger Gebrauch gemacht wird. Auf diese Weise sind durchweg bei Abbildungen aus der Entwicklungsgeschichte ectodermale Gebilde gelbbraun, mesodermale karminrot, entodermale grün, ferner beim Blutkreislauf arterielles Blut ziegelrot, venöses blau, gemischtes violett, schliesslich beim Skelettsystem Knorpel blau usw. angegeben.

BESTELL-ZETTEL

Bei der Buchhandlung .....

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Schimkewitsch, Lehrbuch der Vergleichenden Anatomie der Wirbeltiere.

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There is no BASISPHENOID bone, as just above stated, nor is there an ORBITOSPHENOID.

The ALISPHENOID is bounded by the proötic ventrally, the frontal dorsally and the sphenotic postero-laterally. Its anterior edge forms the dorsal half of the large orbital opening of the brain case, this edge of the bone being, because of the flattening of the hind wall of the orbit, presented almost directly mesially. There is no indication of a parasphenoid leg to the bone. On the dorsal half of the inner surface of the bone there are two brace-like thickenings, the larger one of which underlies the antero-lateral corner of the postepiphysial interspace of cartilage, while the other forms the dorsal end of the anterior wall of the labyrinth recess. The mid-brain recess lies between the two braces. The anterior edge of the bone is either notched, or perforated by a small foramen which must transmit the anterior cerebral vein, though this vein was not traced in the dissections. Not far from the ventral edge of the bone a small opening leads into a canal which traverses the bone and transmits that branch of the ophthalmicus lateralis that innervates the terminal organ of the supra-orbital canal.

The SPHENOTIC is bounded by the alisphenoid, proötic and pterotic, and gives support, on its dorsal surface, to the frontal and postfrontal bones. Its dorso-lateral corner comes to the level of the dorsal surface of the secondary skull, and has surface markings similar to those on the adjacent dermal bones. Between it and the proötic there is a deep facet for the anterior articular head of the hyomandibular, while, posteriorly, between the sphenotic and the pterotic, there is a small dilatator fossa. The bone is traversed by a canal for the ramus oticus facialis, as in Scorpaena.

The DILATATOR OPERCULI, it may here be stated, is found in anterior and posterior portions which are separated from each other by the complete fusion of a suprapreopercular bone with the hyomandibular. The anterior portion arises in the dilatator fossa, is fibrous, with but few muscle fibers, and is inserted on the suprapreopercular and the adjoining portions of the hyomandibular. The posterior portion is muscular, arises from the posterior surface of the suprapreopercular and the adjoining portions of the hyomandibular, ventral to the opercular process of that bone, and has its insertion on the opercular. The fusion of the suprapreopercular with the hyomandibular thus cuts the originally continuous muscle into two portions.

The PROÖTIC is bounded by the alisphenoid, sphenotic, pterotic, exoccipital and basioccipital bones, its ventral edge being overlapped externally by the parasphenoid. The opisthotic does not come into bounding relations with it. The mesial process of the bone inclines strongly upward and corresponds to the postpituitary portion, only, of the processes of Trigla and Scorpaena. The lateral corner of the anterior edge of the process is perforated by the foramen for the nervus abducens. The anterior edge of the body of the bone is perforated, as in Trigla, by a large opening which is the facialis opening of the imperfectly enclosed trigemino-facialis chamber. This chamber forms a deep recess on the orbital surface of the proötic, and from it four foramina usually lead into the cranial cavity. Two of these foramina are large, one of them lying directly dorsal to the other and being separated from it by a delicate bar of bone. The other two foramina are small, one of them lying immediately dorsal to the dorsal one of the two large foramina, and the other one anterior to the line of separation between the two latter foramina. The dorsal one of the two large foramina transmits the nervus trigeminus and ramus buccalis lateralis, the ventral one transmitting the nervus facialis. The small foramen dorsal to the trigeminus foramen transmits the ramus ophthalmicus lateralis, this foramen being sometimes fused with the trigeminus foramen. The other small foramen transmits the ciliaris

profundi and also the encephalic branch of the jugular vein. The antero-ventral edge of the trigemino-facialis chamber is either notched, or perforated by a foramen which transmits the palatinus facialis from the chamber into the myodome, this nerve here, as in Trigla, issuing from the cranial cavity through the facialis foramen and then running forward along the floor of the trigemino-facialis chamber. The edge of the orbital portion of the bone, dorsal to its mesial process, is notched to transmit the oculomotorius, and dorsal to this notch, near the ventral edge of the alisphenoid, there is a second but shallower notch for the nervus trochlearis.

The MYODOME has proötic and basioccipital portions, and, excepting in that the basisphenoid bone and the prepituitary portions of the mesial processes of the proötics are replaced by membrane, the canal is the exact equivalent of the canals of Trigla and Scorpaena. There being no basisphenoid bone, the myodome, in the prepared skull, opens into the hind end of the orbit by a wide median opening, bounded, on either side, by the ascending process of the parasphenoid. In the middle line of the floor of the opening there is the median tooth-like process of the parasphenoid. The hypophysial fenestra extends nearly the full length of the myodome, but is much narrower in the basioccipital region than in the proötic. The fenestra is completely closed by the underlying parasphenoid, the myodome not opening, posteriorly, on the ventral surface of the skull. The roof of the basioccipital portion of the canal is formed by a thin plate of bone, which separates this part of the myodome from the overlying cavum sinus imparis. The cavum sinus imparis extends posteriorly slightly further than the myodome, the pointed ends of both canals being directed toward the point of the conical vertebra-like depression on the hind end of the basioccipital.

The BASIOCCIPITAL is normal, but presents, in median-vertical section, a marked feature. The shallow conical vertebra-like depression in the hind end of the bone, in such sections, is lined by a superficial layer of dense bone differing markedly in appearance from the deeper portions of the bone. A thinner layer of similar bone lines the deeper conical depression, in the anterior end of the bone, that forms the hind end of the myodome. The ends of these two cones approach each other, and the dense bone lining them is continued, in the middle line of the bone, from one cone to the other. In Scomber I described ('03, p. 102) a similar but much less pronounced line, which, in that fish, connected the bottom of the cavum sinus imparis with the vertebra-like depression in the hind end of the basioccipital, and I said that this seemed to indicate that the cavum sinus imparis might be the remnant of the anterior conical depression of a vertebral body. In Peristedion it is not the cavum sinus imparis, but the hind end of the myodome, that has the appearance of being such a depression on the anterior surface of a vertebral element; and if it be such a depression, it would offer a rational explanation of the basioccipital extension of the myodome. That this extension of the myodome is due simply to the fact that the rectus externus, deriving great advantage from a slight additional posterior shifting of its point of origin, has extensively excavated the basioccipital, has never appealed to me. And if a simple posterior extension of its point of origin is of such considerable advantage to the rectus externus, why should it not also be of some advantage to the rectus internus, which muscle, in Scomber and in all of the mail-cheeked fishes that I have examined, never acquires this posterior extension? But, if there were a pre-existing depression in the anterior end of the basioccipital, its occupation and subsequent enlargement by one only of the two muscles would seem most natural. Similar reasoning, applied to the proötic, would account for the origin of the proötic part of the myodome, as will be further discussed in the section devoted to the myodome of fishes.

The cavum sinus imparis extends, in Peristedion, but slightly beyond the middle of the length of the basioccipital, the bone posterior to it having a relatively broad, concave dorsal surface, the posterior portion of which forms the ventral boundary of the foramen magnum and the floor of the cranial cavity immediately anterior to that foramen. Lateral to the cavum sinus imparis the bone lodges a small portion of the short subcircular saccular groove.

The basioccipital is, as usual, bounded dorsally, on either side, by the exoccipital, and anteriorly by the proötic. Ventrally it is overlapped externally by the parasphenoid.

The EXOCCIPITAL is bounded by the basioccipital, proötic, pterotic, opisthotic, epiotic and supraoccipital, and it is perforated by separate foramina for the glossopharyngeus, vagus and occipital nerves. The vagus and occipital foramina have positions similar to those in Trigla, the vagus foramen, in all my specimens, being divided into two parts by a transverse bar of bone. The glossopharyngeus foramen lies directly anterior to the vagus foramen, at one half or two thirds the distance to the anterior edge of the bone. Immediately dorsal to the vagus and glossopharyngeus foramina there is a slight horizontal ridge along the outer surface of the bone; and dorsal to this ridge, nearly the entire lateral surface of the brain case is occupied by a large subtemporal depression which, as in the other fishes of the group, gives origin to the adductor hyomandibularis and adductor operculi muscles, and probably also to the fourth and fifth levators of the branchial arches; but the origins of the levator muscles of the branchial arches were not investigated. The fossa on the proötic so well developed in Scorpaena, is apparently represented, in Peristedion, by a slight groove along the anterior edge of the subtemporal depression.

On the internal surface of the exoccipital there is a mesial process, but it has almost completely coalesced with the lateral wall of the bone, thus here giving to the bone a thick and distinctly double ventral edge which suturates with the basioccipital. At the anterior end of this thick ventral edge, the mesial process separates slightly from the side wall of the bone and so bounds a small dorso-posterior portion of the saccular groove.

The OPISTHOTIC forms part of the thin ventro-laterally projecting portion of the postero-lateral edge of the skull. It lies in a nearly transverse position, filling a large and somewhat square interval between the ventral edge of the posterior process of the pterotic and a right-angled incisure in that portion of the exoccipital that forms part of the postero-lateral edge of the skull. Because of its nearly transverse position, the bone forms part of the flat posterior surface of the skull. A process on its postero-mesial surface gives articulation to the opisthotic process of the suprascapular, suturating with it. The antero-mesial edge of the bone expands, Y-shaped, and overlaps externally the adjoining edges of the pterotic, exoccipital, and epiotic, covering also an interval of cartilage between those bones. The interval of cartilage forms part of the wall of that recess of the cranial cavity that lodges the hind end of the sinus posterior utriculi and the related ampulla posterior. and if the cartilage were to be suppressed the opisthotic would form part of the bounding wall of the recess.

The EPIOTIC is normal.

The PTEROTIC is bounded, in its deeper, primary portion, by the sphenotic, proötic, exoccipital and epiotic, the opisthotic overlapping, externally, the ventral edge of that part of the pterotic that encloses the posterior portion of the external semicircular canal. The dermal portion of the bone is bounded by the frontal, postfrontal, parieto-extrascapular, lateral extrascapular and

suprascapular. The primary portion of the bone encloses, as usual, the outer portion of the horizontal semicircular canal. On the lateral surface of this part of the bone, near its dorsal edge, is the facet for the posterior articular head of the hyomandibular. Dorso-anterior to this facet, a small pit-like depression forms the posterior half of the dilatator fossa. The posterior process of the bone is relatively small, is directed ventro-laterally and but slightly posteriorly, and is in contact with the dorsal edge of the opisthotic. The dermal portion of the bone is traversed by the main infraorbital canal, the section of canal enclosed in the bone lodging one organ innervated by the oticus, and quite certainly, though this could not be positively determined, a second, post-preopercular organ innervated by the supratemporalis lateralis vagi. The primary tubes indicate the presence of two organs here, one tube arising from the canal at the anterior edge of the bone, another at the hind edge of the bone, and a third slightly anterior to the middle of the bone; this latter tube issuing from the bone on its lateral edge, immediately posterior to the facet for the posterior head of the hyomandibular, and anastomosing with the dorsal end of the preopercular canal. The post-preopercular organ must, if present, be a small one, for it could not be definitely recognized in any of the dissections, although a branch of the supratemporal branch of the vagus, which nerve contains lateralis fibers, was always found perforating the pterotic, and going to that part of the canal where the organ would be found, if present.

On the lateral edge of the pterotic, immediately posterior to the opening of the primary tube that anastomoses with the preopercular canal, there is a large, slightly convex surface, marked with striae. This surface lies on a slightly elevated portion of the bone, lies mainly on the primary portion of the bone, and gives a sliding articulation to the dorsal edges of the united suprapreopercular and hyomandibular.

The SUPRAOCCIPITAL has dorsal and ventral limbs, the dorsal limb being entirely covered by the frontals and parieto-extrascapulars, excepting only a small median portion of its hind edge. The anterior edge of this limb of the bone bounds the hind edge of the postepiphysial cartilage. The ventral limb of the bone has a prolonged median portion which extends nearly to the dorsal edge of the foramen magnum. This prolongation of the bone lies upon the external surface of the adjoining edges of the exoccipitals and on the narrow median band of cartilage that separates those bones, thus apparently being of ectosteal origin. In its dorsal portion the ventral limb of the bone expands and is in contact with the exoccipitals and epiotics. In the median line, near the dorsal end of the limb, there is a small vertical ridge which represents the slightly developed spina occipitalis.

2. INFRAORBITAL BONES.

The infraorbital bones are five in number, all of them traversed by the main infraorbital canal. The anterior bone, or lachrymal, lodges four sense organs of the line, the second bone one organ, the third bone two organs, and the fourth and fifth bones one organ each. The total number of organs enclosed in these bones is thus nine, that being the total number also in both Trigla hirundo and T. lyra. The lateio-sensory ossicles are not however interfused in the same manner in either of these three fishes, as the following table will show. The young Trigla lyra, given in this table, is assumed to have six bones in the series, as Günther says it has, and the arrangement of the organs in this fish is hypothetical, as all of my fishes had but five bones.

Bones	T. lyra (young)	T. lyra (old)	Peristedion	T. hirundo (young)	T. hirundo (old)
1st.	3 organs	4 organs	4 organs	3 organs	7 organs
2nd.	1 ,,				
3rd.	1 ,,	1 ,,	1 ,,	4 ,,	
4th.	2 ,,	2 ,,	2 ,,		
5th.	1 ,,	1 ,,	1 ,,	1 ,,	1 ,,
6th.	1 ,,	1 ,,	1 ,,	1 ,,	1 ,,

The lachrymal, in Peristedion, has a long, flat, spatula-shaped anterior portion, which forms the preorbital process of the skull, and an equally long, but slender and tapering process-like posterior portion. The spatula-shaped portion projects, its full length, beyond the anterior end of the cranium; and is marked with surface granulations on both its dorsal and ventral surfaces. It is traversed, in a somewhat peculiar manner, by the main infraorbital canal. This canal begins at a long groove on the dorsal surface of the spatula-shaped portion of the bone, the groove beginning at the hind end of that part of the bone, near its mesial edge, and from there running forward a short distance parallel to the mesial edge of the bone. The hind end of the groove lies immediately antero-mesial to the antero-lateral corner of the nasal bone, and hence immediately antero-mesial also to the first pore of the supraorbital canal. The groove is covered, in the recent state, by a drum-head-like membrane perforated by one or more small pores, and represents the first primary tube of the main infraorbital canal. From there the canal runs forward to the anterior end of the bone, where it curves latero-posteriorly and then runs backward to the hind end of the spatula-shaped portion of the bone. There it leaves the bone, lateral to its posterior, process-like portion, to enter the second bone of the infra-orbital series. On the ventral surface of the bone, three large oval openings lead into the canal, each closed by a perforated drum-head-like membrane, these openings representing the 2nd., 3rd. and 4th. primary tubes of the line. The 5th. tube of the line lies between the lachrymal and the 2nd. infraorbital bone, and it also opens on the ventral surface of the snout; the 6th. tube being the first one to open on the dorso-lateral surface of the skull. This opening of these first five tubes of the line, on the ventral surface of a portion of the snout of the fish, associated, as it is, with a mouth that also lies on the ventral surface of the snout and is supplied with barbels, strongly recalls the conditions found in Acipenser and Scaphyrhynchus.

The process-like posterior portion of the lachrymal lies along the dorso-mesial edge of the second infraorbital bone, over-lapping that bone internally. Its pointed posterior end passes beyond the second bone and there rests upon the external surface of the dorso-mesial edge of the dermo-ectopterygoid. The base of this posterior portion of the lachrymal is slightly grooved on its mesial edge and this groove is continued forward along the mesial and anterior edges of a flat depression, with a curved anterior edge, that lies on the ventral surface of the base of the anterior, spatula-shaped portion of the bone. The groove and depression lodge the flattened maxillary process of the palatine and a short adjoining portion of the slender body of that bone, the two bones being firmly bound together. Posterior to this groove, the lachrymal and palatine are, for a short distance, not in direct contact, a slit-like opening being left between them; this opening lying opposite the nasal pit and lodging the lateral portion of the nasal sac. Posterior to this nasal opening the two bones again come into contact, the rod-like hind end of the palatine lying in a narrow space between the lachrymal

externally and the anterior end of the ectopterygoid internally; the three bones being firmly bound together. Posterior to the palatine, and in the same narrow space between the lachrymal and ectopterygoid, a narrow rod of cartilage continues backward and soon expands into a large flat piece of cartilage which lies against the inner surface of that part of the ectopterygoid that bears the dermo-ectopterygoid.

The second infraorbital bone is V-shaped, the hollow of the V embracing the bluntly pointed anterior end of the third bone of the series. The hind end of the dorsal limb of the V is rounded, and rests upon the external surface of the dermo-ectopterygoid. The hind end of the ventral limb is slightly grooved on its inner surface, and this groove receives the anterior end of a pointed anterior process of the quadrate, the two bones being strongly bound together but a slight sliding movement being permitted. The hind end of the second infraorbital, in some specimens, abuts against, while in others it does not quite reach, the anterior end of the ventral limb of the preopercular. The main infraorbital canal enters the bone at its anterior end, and leaves it at the point of the angle between its two limbs, one sense organ being found in the section of canal so enclosed. On the outer surface of the bone, near the middle of its length, there are two or three spines, these spines lying on the horizontal ridge already described, and that ridge marking the course of the latero-sensory canal in the bone.

The third infraorbital bone is large and somewhat parallelogrammic in shape. Its ventral end is in contact with the dorsal edge of the ventral limb of the second bone of the series, the ventral half of its anterior edge being in contact with the postero-ventral edge of the dorsal limb of the same bone. The dorsal half of its anterior edge rests upon the outer surface of the dermo-ectopterygoid, a small portion of the latter bone coming to the level of the outer surface of the infraorbital bones, being similarly marked with surface granulations, and appearing as a prolongation of the dorsal limb of the second infraorbital bone. The hind edge of the third infraorbital bone overlaps internally and rests against the anterior edge of the ventral half of the preopercular. The anterior portion of its dorsal edge is thickened, and bevelled on its inner surface, this bevelled surface having a sliding articulation on that free ventral edge of the ectethmoid that lies posterior to the posterior palatine articular surface of that bone. The posterior portion of the dorsal edge of the infraorbital bone lies internal to the fourth infraorbital, the latter bone lying in a large depressed region on the external surface of the third bone. The bone is traversed by the main infraorbital canal and lodges two sensory organs of the line.

The fourth infraorbital is a rhomboidal bone traversed by the main infraorbital canal, and lodging one organ of that line. It forms almost the entire ventral margin of the orbit, overlaps externally the third infraorbital, and is bounded both anteriorly and ventrally by that bone. Posteriorly, it overlaps externally and rests upon the outer surface of a flange of the hyomandibular, its hind edge abutting against the anterior edge of the preopercular, and its dorso-posterior corner being in contact with the fifth bone of the infraorbital series. On its outer surface there is a low, sharp and finely serrated longitudinal ridge, which lies superficial to, or slightly dorsal to the enclosed section of the latero-sensory canal.

The fifth infraorbital is a triangular bone that forms the hind margin of the orbit and transmits the main infraorbital canal from the fourth infraorbital to the postfrontal, lodging one organ of the line. Its hind edge rests upon the outer surface of the shank of the hyomandibular, and, in specimens that have been preserved in alcohol, is so firmly attached to that bone that it appears in process

of ankylosis with it. Ventrally it is in contact with the fourth infraorbital. Posteriorly its ventral half abuts against the dorsal portion of the anterior edge of the preopercular, its dorsal portion abutting against the anterior edge of the suprapreopercular bone. The dorsal end of the fifth infraorbital does not quite reach the lateral end of the postfrontal.

3. SUSPENSORIAL APPARATUS AND MANDIBLE.

The PREOPERCULAR is a large, stout and irregular bone. On its outer surface, slightly below its middle point, there is a thin and relatively tall ridge, already referred to, which crosses the bone horizontally, from one edge to the other, increasing gradually in height from in front backward; and that part of the bone that lies ventral to the ridge inclines ventro-mesially at a marked angle to the part that lies dorsal to it. The bone is traversed by the preopercular latero-sensory canal, that canal presenting two straight limbs, a dorsal and a ventral one, which unite at an angle that lies beneath the horizontal ridge on the outer surface of the bone. The canal lodges six sense organs.

On the inner surface of the preopercular, following the angular course of the latero-sensory canal, a flange arises from the bone, the dorsal portion of this flange projecting antero-mesially and the ventral portion projecting dorsally or dorso-mesially, the two portions of the flange lying at the same marked angle to each other that the two limbs of the latero-sensory canal do. In the angle between the two portions of the flange there is a concave surface which lodges the cartilaginous interspace between the hyomandibular and symplectic. Dorsal to this concave surface, in the angular space between the dorsal limb of the flange and the internal surface of the anterior edge of the bone, this angle being presented anteriorly, the ventral three-fifths of the hyomandibular is lodged. Against the lateral, or dorso-lateral surface of the anterior half of the ventral limb of the flange, the broad flat ventral surface of the posterior process of the quadrate rests; both the quadrate and the hyomandibular being firmly attached to the preopercular.

The HYOMANDIBULAR has, in alcoholic specimens, two dermal bones almost inseparably fused with its outer surface. The lines of separation between these dermal bones and the underlying hyomandibular can be everywhere traced, but the two bones could not be removed, without breakage, in any of the specimens examined, all of which had been preserved in alcohol and then slightly boiled. One of these two dermal bones is the fifth one of the infraorbital series, and the other the suprapreopercular. As already stated, the hind edge of the fifth infraorbital bone rests upon the lateral surface of a flange on the anterior edge of the hyomandibular. This flange arises from a stout longitudinal ridge on the lateral surface of the bone — this ridge being the homologue of the one already described in the other fishes of the group — and between the flange and the anterior edge of the body of the bone there is a V-shaped space, the hollow of the V directed anteriorly and forming the hind end of the flat space included, as in Trigla, between the cheek-bones, externally, and the palato-quadrate internally. In the hollow of this V, near its ventral end, and hence anterior to the longitudinal ridge on the lateral surface of the bone, the canal for the hyoideo-mandibularis facialis opens, having traversed the bone from its internal surface. The longitudinal ridge on the lateral surface of the bone inclines backward, its summit fitting into the V-shaped groove on the anterior edge of the dorsal limb of the preopercular. The fifth infraorbital was broken and picked off in the specimen used for the figures.

The SUPRAPREOPERCULAR is in contact, by its ventral edge, with the dorsal end of the preopercular, and is partly traversed by, and in part forms a bounding wall of the dorsal end of the preopercular latero-sensory canal; but it lodges no organ of that canal. Its dorsal end lies immediately behind the posterior articular head of the hyomandibular, and this end of the suprapreopercular is firmly attached to a flange of bone that fills the obtuse angle between the posterior articular head of the hyomandibular and its opercular articular head, a circular passage being left between the two bones to transmit the dorsal end of the preopercular canal. The coinciding dorsal edges of the suprapreopercular, and the flange of the hyomandibular to which it is attached, form a broad surface which is slightly concave, is marked with transverse striae, and articulates with the lateral edge of the pterotic. The articulation is, accordingly, in part with a dermal bone, probably of latero-sensory origin, and in part with a portion of the hyomandibular that is apparently of membrane origin. This latter articulation, with a portion of the hyomandibular that is apparently of membrane origin, is found alone, but much more developed, in Dactylopterus. The intimate attachment of the suprapreopercular to the hyomandibular has not only completely blocked the passage for the dilatator operculi muscle, but has cut that muscle into anterior and posterior portions, as already described.

The anterior and posterior articular heads of the hyomandibular lie close together, on the dorsal end of the bone, separated by a narrow roughened surface that has the appearance of dermal bone. The opercular articular head is long and slender, and is connected, by a wide web of bone, with the ventral portion of the shank. The bone is traversed by the canal for the hyoideo-mandibularis facialis, a single small branch canal transmitting a nerve destined to innervate, as in the other fishes described, certain organs in the preopercular.

The SYMPLECTIC is a slender bone, with a flattened distal end which lies in the symplectic groove on the inner surface of the quadrate. Between this flattened distal portion and the proximal end of the bone, the symplectic arches slightly, leaving a long but narrow space between itself and the preopercular, this space transmitting the ramus mandibularis externus facialis and the arteria hyoidea. The mandibularis internus facialis passes anterior to the symplectic, between that bone and the hind edge of the quadrate, as in the other fishes of the group.

The hyomandibulo-symplectic interspace of cartilage lies in the little concave surface in the angle between the dorsal and ventral limbs of the flange on the inner surface of the preopercular, as already stated, but it occupies only the dorsal portion of the concavity. Ventral to it, the remainder of the concavity lodges the small interhyal, that element articulating with the cartilage in a little facet on its ventro-posterior surface. In the corner between the cartilage, the inner surface of the preopercular, and the ventro-posterior corner of the hyomandibular, there is a small opening which transmits the ramus hyoideus facialis.

The QUADRATE has a well developed posterior process, and on the lateral surface of the postero-ventral edge of this process there is a wide, flat flange. This flange projects dorso-laterally at an acute angle to the flat, plate-like body of the bone, and its anterior end is prolonged forward beyond the anterior edge of the body of the bone as a strong anterior process. The ventro-posterior surface of the body of the flange fits, in larger part, against the internal surface of the ventro-anterior end of the preopercular, in the angular groove between the body of the bone and the ventral limb of the flange on its internal surface; but a small anterior portion of this surface fits against the internal

surface of the third bone of the infraorbital series. The anterior prolongation of the flange rests upon and is firmly bound to the internal surface of the ventral limb of the second infraorbital bone. The posterior process of the quadrate occupies the anterior half only of the ventral limb of the angular groove on the preopercular, and the articular head of the bone projects beyond the anterior end of the preopercular and is there exposed on the external surface of the apparatus in an angular notch in the ventro-anterior corner of the preopercular. On the internal surface of the quadrate, there is a shallow symplectic groove.

The METAPTERYGOID has a long and slender dorso-posterior process, the dorsal end of which closely approaches and is bound by tissue to a thin web of bone on the anterior edge of the hyomandibular; this process thus being the internal flange on the hind edge of the bone. At the base of the process there is a slightly developed external flange, the hind edges of both flanges being widely separated from the anterior edge of the hyomandibular. In the V-shaped space between the two flanges a portion of the levator arcus palatini has its insertion. The ventro-anterior edge of the bone is everywhere separated from the quadrate by a narrow line of cartilage, the posterior corner of this edge of the bone being in contact with the symplectic.

The ENTOPTERYGOID is a small, thin plate of bone which lies in the membrane that covers the ventral surface of the adductor arcus palatini muscle. Its ventral edge rests against the inner surface of the narrow band of cartilage that lies between the quadrate and metapterygoid, usually extending forward slightly beyond that cartilage onto the inner surface of the ectopterygoid. Its hind edge overlaps slightly the inner surface of the metapterygoid.

The ECTOPTERYGOID is a stout bone, with the usual dorsal and ventral limbs lying at an angle to each other. The two limbs of the bone form a thin plate, which is completely ankylosed, at the angle between the two limbs, with a plate of bone which is certainly of separate origin, and which has been already referred to as the dermo-ectopterygoid. The ventral limb of the bone has the usual position along the internal surface of the anterior edge of the quadrate, the dorsal limb lying along the ventral and outer surfaces of the hind end of the palatine, and also along the same surfaces of the palatine cartilage.

The DERMO-ECTOPTERYGOID lies on the external surface of the thin plate formed by the two limbs of the membrane-ectopterygoid, and extends from the angle between the two limbs of that bone forward along the dorsal limb. It projects dorsally beyond the membrane-ectopterygoid, along the lateral surface of the enlarged posterior portion of the palatine cartilage, and then beyond that cartilage, there forming an important angle in the apparatus. The ectal surface of the bone is presented dorso-laterally, and the posterior half of this surface lies against and is firmly bound to the inner surface of the antero-dorsal corner of the third infraorbital bone. A small anterior portion of the plate lies against but is much less firmly bound to the inner surface of the hind end of the dorsal limb of the second infraorbital bone. Between these two surfaces of contact with the infraorbital bones, the outer surface of the plate is granulated and comes to the level of and forms part of the outer surface of the bony cuirass of the cheek. The dorsal edge of the plate is presented dorso-mesially, and its thick posterior portion is grooved, the groove articulating with the articular ridge near the hind end of the lateral edge of the ectethmoid. Anterior to this groove the dorsal edge of the plate is thin, and lies against the lateral surface of the rod of palatine cartilage, the latter cartilage not coming into articular relations with the ectethmoid. On this thin portion of the dorsal edge of the

bone, and also on the mesial edge of the grooved portion posterior to it, rests the slender pointed hind end of the posterior, process-like portion of the lachrymal. This end of the lachrymal is grooved on its dorso-external surface, and participates in the articulation with the ectethmoid, the articulation thus representing the lachrymo-ethmoid articulation of the other fishes described. The dermo-ectopterygoid, completely ankylosed with the ectopterygoid, thus fulfils the function of the posterior ethmoid process of the palatine of both Scorpaena and Trigla; but nevertheless the bone does not seem to be a palatine element, its relations to the ectopterygoid being much more intimate than those to the palatine.

The PALATINE is a slender rod of bone with an enlarged and flattened anterior end. The ventral surface of the hind end of the rod-like portion of the bone rests against the dorso-mesial surface of the dermo-ectopterygoid, as just above described. The lateral surface of this end of the palatine, or the lateral surface of the covering dermo-ectopterygoid, and the lateral surface also of the anterior portion of the palatine, rest against the internal surface of the posterior, process-like portion of the lachrymal, the slit-like opening between these two surfaces of contact lodging the lateral portion of the nasal sac. In the angle between the rod-like part of the bone and its enlarged anterior end, on the mesial surface of the bone, there is a concave articular surface, with a slight process at its anterior edge. This articular surface hooks around and articulates with the anterior edge of the little anterior palatine eminence of the ethmoid cartilage. Anterior to this articular surface, the anterior end of the palatine widens, its mesial edge being slightly concave and its anterior edge rounded and capped with cartilage. This part of the palatine forms its maxillary process, and fits in the depression and groove, already described, on the ventral surface of the base of the spatula-like anterior portion of the lachrymal. Between the curved mesial edge of this maxillary process of the bone and the lateral portion of the anterior edge of the vomer, a semi-oval space is enclosed, through which the ascending process of the maxillary projects from below upward; this process of the maxillary articulating by one surface with the vomer and by the other with the palatine, and being bound to both bones by connective tissue.

The OPERCULAR has the irregular shape shown in the figures. On the inner surface of the anterior edge of the bone there is a deep depression which receives the opercular articular process of the hyomandibular. Dorso-posterior to this depression there is a larger depression on the inner surface of a dorsal, process-like portion of the bone, this depression giving insertion to the adductor operculi. Dorsal to the surface of insertion of this latter muscle, in a narrow line along the dorsal edge of the bone, the levator operculi has its insertion. The dilatator operculi is inserted on the anterior edge of the bone, immediately lateral to the articular facet for the hyomandibular. On the outer surface of the bone there is a horizontal ridge which terminates posteriorly in a spine, this spine being double in one of my specimens. Dorsal to this spine there is, on the hind edge of the bone, a second spine.

The SUBOPERCULAR is a delicate bone that lies along the inner surface of the hind edge of the opercular, projecting dorsally beyond the dorsal edge of that bone.

The INTEROPERCULAR lies along the inner surface of the preopercular, considerably anterior to, and wholly detached from the opercular and subopercular. Its antero-ventral end is slender and rod-like, and almost reaches, and is bound by ligament to, the hind end of the mandible. Its dorso-posterior portion is flat and broad, and lies against and is firmly bound by ligament to the lateral

surface of the proximal end of the ceratohyal, near the point where that bone articulates with the interhyal; the attachment apparently being to the interhyal as well as to the ceratohyal. From the dorso-posterior end of the interopercular a stout ligament arises, and running dorsally, parallel to and immediately posterior to the interhyal, is inserted on the inner surface of the preopercular.

The MANDIBLE is strongly curved at its anterior end, to meet, in the middle line, its fellow of the opposite side. Its middle point lies considerably posterior to the corresponding point of the upper jaw, and the dentary, like the maxillary, the premaxillary, and the vomer is wholly without teeth. The articular has a pointed anterior end which projects slightly beyond the hollow of the V between the dorsal and ventral limbs of the dentary, and there lies internal to that bone. Posterior to this point, the ventral edge of this portion of the articular slightly overlaps, externally, the dorsal edge of the ventral limb of the dentary. On the internal surface of the bone, posterior to the hind end of Meckel's cartilage, there is a slight eminence for the insertion of the tendon of a part of the adductor mandibulae muscle. The bone has a broad thin coronoid process. The angular is almost completely fused with the articular, a sutural line on the external surface of the bone alone indicating its presence. The dentary has a long and slender dorsal limb which does not reach, by a considerable interval, the dorsal end of the coronoid process. On the lateral surface of the dorsal edge of the dentary, slightly anterior to the middle of its length, there is a dorso-laterally projecting shelf of bone: and immediately beneath this shelf, on the external surface of the bone, there is the large anterior opening of a short canal which leads backward through the dentary into the ramus of the mandible. This canal transmits a large nerve which goes immediately to the large barbel of the fish, this barbel having its attachment on the outer surface of the dentary in a pit-like depression that lies immediately ventral to the anterior end of the projecting shelf of bone. On the projecting antero-lateral corner of this shelf of bone the mandibular labial fold has its origin. The barbel of Peristedion thus arises from the mandible in the place where the gristle-like core of the mandibular fold of Scorpaena arises, and, contiguous with it, the mandibular fold has its origin. Whether this means that the core of the mandibular fold of Scorpaena represents, or includes, the barbel of Peristedion, or not, I can not determine.

The dentary and articular are both traversed by the mandibular latero-sensory canal, the dentary lodging three sense organs of the line, and the articular one organ.

4. LATERO-SENSORY CANALS.

The main infraorbital canal has the course already described through the infraorbital bones, the lachrymal lodging four organs of the line, the second infraorbital bone one organ, the third bone two organs, and the fourth and fifth bones one organ each; making nine organs in all in this part of the line, that being the same number as in Trigla. The canal then traverses the postfrontal, in which bone there is a single organ innervated by a branch of the oticus lateralis, and then anastomes with the penultimate tube of the supraorbital canal. The canal then traverses the pterotic, in which bone there is a large pre-preopercular organ innervated by a branch of the oticus lateralis, and in all probability a second and much smaller post-preopercular organ innervated by a branch of the supratemporalis lateralis vagi. A branch of the latter nerve was found going to the canal in four different specimens, but the organ, if it exists, is so small that it could not be with certainty identified. The canal anastomoses with the dorsal end of the preopercular canal between these two organs.

Having left the pterotic, the canal traverses a groove in the lateral edge of the lateral extrascapular, but no organ could be found related to that bone. The canal then traverses in succession the suprascapular and supraclavicular, in each of which bones there is a single organ.

The main infraorbital canal of Peristedion thus differs from that of Trigla in that the pterotic lodges but one organ innervated by the oticus lateralis, instead of two, without intervening primary tube; and in that there is no apparent organ related to the lateral extrascapular.

The supratemporal canal lodges, as in all the other fishes of the group, two organs, one lying in the lateral extrascapular and the other in the parieto-extrascapular.

The supraorbital canal agrees strictly with the canal in Scorpaena and Trigla, but between the nasal and frontal bones the canal is enclosed, for a relatively long distance, in the dermal portion of the mesethmoid bone; this section of canal lodging no sense organ. The nasal lodges a single sense organ, and the frontal five organs, the fourth and fifth organs of the line lying close together without intervening primary tube, as in Scorpaena and Trigla. The fourth primary tubes of opposite sides unite in the middle line to form a frontal commissure.

The preoperculo-mandibular canal contains ten organs, instead of eleven as in Trigla, three of these organs lying in the dentary, one in the articular and six in the preopercular. After leaving the dorsal end of the preopercular the canal traverses a short suprapreopercular bone, without related organ, to reach and anastomose with the main infraorbital canal between the two organs in the pterotic.

The primary tubes, in Peristedion, do not branch repeatedly after entering the dermal tissues, as they do in Scorpaena, Cottus and Trigla. Certain of the tubes, however, apparently undergo one or two subdivisions, and the mouths of all of them become enlarged and most of them are closed by drum-head-like membranes perforated by several small openings.

IV. Dactylopterus volitans.

1. SKULL.

Of this fish I have had five specimens, ranging from 13 cm to 41 cm in length, and a number of specimens ranging from 5 cm to 10 cm in length. A single one of these specimens, 35 cm in length, was the only one I had during the earlier periods of the investigation, the other large specimens being later obtained, one at a time. The study of the cranial bones presenting peculiar difficulties, all of these large specimens were successively sacrificed to it, the soft parts thus not being examined in any of the adults. When the small specimens were later obtained, several of them were sectioned, but, because of the character of the bones and other tissues, only one comparatively good series of sections was obtained. This series alone served for the study of the nerves.

Gill ('90, p. 245) says, of the skull of Dactylopterus, that „its upper surface is derived partly from a dermal ossification which is incongruous with the true bones". Just what this statement means is not clear, for the bones in this fish differ in no way, excepting in degree, from those in Trigla and Peristedion. As in these two latter fishes, all of the primary bones that come to the level of, and form part of the dorsal surface of the skull of Dactylopterus have an external surface exactly similar to that of the adjoining and purely dermal bones; and the sections of young Dactylopterus

show, better even than those of the other fishes of the group, that this external portion of these primary bones is formed by osseous accretions that are apparently developed in exactly the same way as the corresponding portions of the purely dermal bones. A 13 cm specimen was treated with chlorine, in an early attempt to trace the sutures between the cranial bones, and in this preparation a superficial layer of bone could be stripped off from both the purely dermal and the primary bones, leaving, in the former case, a thin remaining plate of bone which may perhaps represent a separate, membrane component underlying a more important dermal or latero-sensory component. This membrane component would then be the part that persists in those higher animals in which the latero-sensory component has disappeared.

The skull of Dactylopterus is said by Cuvier & Valenciennes ('29, vol. 4, p. 131) to be depressed and widened in such a manner that it represents a subrectangular disk, the anterior edge of which is curved in an obtuse angle, and its posterior angles prolonged into long points. A very large median ethmoid and two prefrontals are said to form an anterior row of the bones that form the pavement-like dorsal surface of the skull. A second row is said to be formed by the large frontals, behind each of which bones there is a small postfrontal. A third row is formed by the median interparietal, the two parietals, and the two mastoids; and a fourth row by the two external occipitals and two suprascapulars. Between the third and fourth rows, on either side, two oval bones are said to be intercalated, these two bones together, on each side, representing the „rocher".

The prefrontals of this terminology are the ectethmoids of the nomenclature employed by me, the interparietal is the supraoccipital, and the mastoid is the pterotic. The term „rocher", as used by earlier authors, is said by Starks ('01) to be the synonym of the opisthotic of later authors; but it will be shown that the so-called „rocher" of Dactylopterus is the lateral extrascapular, and not the opisthotic of the fish, this latter bone being wholly absent. It will be further shown that the external occipital is a mesial extrascapular, and not an epiotic; and, what is much more important, it will be shown that the median ethmoid is not an ethmoid bone at all, but is a median bone formed by the fusion, in the middle line, of the two nasals.

Gill ('88) calls the median ethmoid of Cuvier and Valenciennes the prosethmoid, and says that it and the anteal (vomer) are „entirely disconnected, leaving a capacious rostral chamber opening backwards mesially into the interorbital region". Into this rostral chamber the well developed ascending pedicles of the intermaxillines (premaxillaries) are said to glide. And as Gill, in his descriptions of the Loricati, says that the ascending pedicles of the intermaxillines glide „over the front of the prosethmoid", the term prosethmoid, as used in his descriptions of Dactylopterus, is certainly intended by him to designate a bone that he considered as the strict homologue of the median, primary mesethmoid of current descriptions. No mention is made of a rostral either by Gill or by Cuvier and Valenciennes.

The floor of the rostral chamber, in my medium-sized specimens, inclines downward and forward at an angle of about 45°. In the 41 cm and 35 cm specimens this floor is somewhat less steep, while in the small specimens it is much steeper. In the middle line of the anterior half of the floor, there is a narrow strip of cartilage formed by a median rod-like projection from the anterior end of the antorbital cartilage. This rod-like process is the strict homologue of the prenasal process, or beak, of my descriptions of Amia and Scomber, but it is here a relatively long and narrow rod, curving downward and forward. It lies in a median groove on the dorsal surface of the vomer, and extends to the anterior edge of that bone, agreeing in this with the arrangement found in Scomber.

On either side of this median rod of cartilage, the dorsal surface of the vomer forms the floor of the anterior half of the rostral chamber. Posterior to the vomer, the antorbital cartilage expands rapidly, on either side, and then again contracts to a narrow median column which is continuous dorsally with the ventral surface of the anterior end of a broad band of cartilage which forms the roof of the interorbital, olfactory prolongation of the cranial cavity. A diamond-shaped or nearly square surface of cartilage thus forms the median portion of the post-vomerine portion of the floor of the rostral chamber, this cartilage being bounded laterally, on either side, by the pedicle of the ectethmoid. There is thus no bone whatever at any point in the median line of the floor of the chamber.

The hind wall of the rostral chamber is formed by the median column of cartilage just above referred to, and, dorsal to that column, by the broad anterior end of the roofing band of interorbital cartilage. This anterior end of this latter cartilage projects forward slightly beyond the median column, slightly overhangs the hind end of the rostral chamber, and gives support, on its dorsal surface, to the hind end of the so-called median ethmoid. Immediately beneath this part of the median ethmoid there is, on either side, a slight eminence on the anterior edge of the cartilage, each eminence giving origin to a ligament which runs antero-ventrally and is inserted on the dorsal surface of the maxillary immediately lateral to its ascending process. This ligament is thus the homologue of the ethmo-maxillary ligament of the other fishes of the group, and the little eminence of cartilage from which it has its origin must accordingly be the mesethmoid process; but it is a process of the ethmoid cartilage only, there being no primary bone whatever in any immediate relation to it. On a slight median ridge in the cartilaginous floor of the chamber, the ventral surface of the rostral glides. There is accordingly, in this fish, no mesethmoid bone. That the median portion of the ethmoid cartilage should remain unossified, and that a median ethmoid bone, of primary origin, should nevertheless be found wholly external to that cartilage, dorsal to the rostral instead of ventral to it, and dorsal even to the mesethmoid processes of the ethmoid cartilage, is evidently impossible.

The roof of the rostral chamber is formed by the single median so-called ethmoid or proseth-moid. This bone suturates posteriorly with the frontals. Laterally, on either side, it suturates, in its posterior half, with the ectethmoid, while in its anterior half it forms the mesial boundary of an elongated nasal opening; which opening lies between this so-called ethmoid and the anterior portion of the ectethmoid, opens directly into the nasal pit and encloses the two nasal apertures. At the anterior end of the opening, the two bounding bones closely approach each other, but do not quite come into contact, a narrow space being left between them, closed antero-ventrally by the lachrymal.

Slightly antero-mesial to the nasal opening, there is, on the anterior edge of the so-called ethmoid, a short, broad, stout process which projects ventrally and antero-laterally. This process arises from the deeper layers only of the bone, the anterior edge of that superficial portion of the bone that bears the surface markings continuing, uninterruptedly, external to it. The internal surface of the process forms a large flat articular surface which gives a sliding articulation to the flattened anterior end of the maxillary process of the palatine. On its external surface the process gives support to the internal surface of the dorsal edge of the lachrymal, the two bones being strongly but somewhat loosely bound together by fibrous tissue, a slight sliding and oscillating motion, combined, of the lachrymal being permitted. The process thus corresponds, in its relations to the palatine and lachry-mal bones, to the process-like antero-lateral corner of the nasal bones of Trigla and Peristedion, excepting that here, in Dactylopterus, it is developed as a process-like prolongation of the ventral layers of the bone, and is interposed between the palatine and lachrymal instead of lying on the

dorsal surfaces of those two bones. The process may accordingly be called the lachrymo-palatine process of the bone. From its postero-lateral edge, on the internal surface of the body of the bone, a tall sharp ridge begins, and running postero-mesially, nearly to the hind end of the bone, marks the boundary between the dorsal portions of the rostral chamber and the nasal pit; those two chambers being confluent beneath the ridge. Between the hind ends of the ridges of opposite sides there is, on the internal surface of the bone, a deep median pit which nearly perforates the bone and lodges the distal ends of the ascending processes of the premaxillaries. Immediately postero-lateral to the lachrymo-palatine process, close to the narrow space that leads into the nasal opening, the supra-orbital latero-sensory canal begins, and running at first dorso-mesially and then curving posteriorly, traverses the bone and issues at its hind edge, there entering the frontal. This median so-called ethmoid or prosethmoid bone of Dactylopterus is thus certainly a bone formed by the fusion, in the median line, of the two nasal bones of the fish.

The ROSTRAL is a narrow, flat and tall cartilage, which lies between the hind ends of the articular processes of the premaxillaries, and gives support, on its dorsal edge, to the ascending processes of those same bones. Its ventral edge has a slight median groove, and this groove slides upon a slight median ridge on the cartilaginous floor of the rostral chamber. The rostral is relatively small, as are also the maxillary and premaxillary bones; and all of these elements of the upper jaw of the fish are entirely concealed, in dorsal and lateral views, beneath the nasal and lachrymal bones.

The PREMAXILLARY has a long, flat and pointed ascending process, a relatively long, large and flat articular process, and a short and flat horizontal portion, or body. The short body of the bone ends in a broad blunt end, and its flat oral surface is garnished its full length, or very nearly so, with small villiform teeth. The ascending process arises by a broad base from the mesial (proximal) end of the body of the bone, and, in the medium-sized specimens, is directed dorsally and but slightly backward. It lies in a nearly longitudinal plane, inclining and but slightly ventro-mesially, the flat surfaces of the processes of opposite sides enclosing between them a deep and narrow groove. The long flat articular process also lies in a nearly longitudinal plane, inclined at a slight angle to the ascending process, the two processes projecting dorso-posteriorly nearly parallel to each other and separated by a narrow intervening space. From the distal surface of the base of the ascending process a rod of tough gristly tissue arises, and extending distally along the dorsal surface of the body of the bone, is attached, at its distal end, to the distal end of the maxillary. This rod of gristly tissue lies in the upper labial, or maxillary dermal fold, thus occupying a position that corresponds to that occupied by a considerable part of the body of the premaxillary in the other fishes of the group, the actual body of the premaxillary of Dactylopterus corresponding, not to the premaxillaries of the other mail-cheeked fishes, but, approximately, to the premaxillaries of those fishes in which the maxillary is said by Sagemehl to lie lateral (distal) to the premaxillary.

The MAXILLARY has a relatively large, right-angled ascending process, similar to that of Scorpaena, and a short broad ligamentary process which corresponds to the proximal half only of the process of Scorpaena. The distal end of the short and slender body of the bone is slightly expanded, gives attachment to the hind end of the upper labial rod of gristly tissue, and lies in a marked depression on the outer surface of the mandible. The bone articulates with the premaxillary and vomer in the same way that it does in Scorpaena, and it gives articulation, on the dorsal surface of its ligamentary process and the adjacent portions of its body and ascending process, to the anterior

end of the maxillary process of the palatine. It does not give support, at any point, to the lachrymal; but a short, strong ligament extends from the summit of the ascending process of the bone to the dorsal edge of the lachrymal, this ligament having its attachment also in part on the lachrymo-palatine process of the nasal.

The LIGAMENTS associated with the upper jaw were not properly investigated, the smaller specimens not being suitable for this investigation, and the skeletons of the larger specimens having been prepared, as already stated, without special attention being given to any of the soft parts. The ethmo-maxillary ligament is well developed, even in the small adults, and has already been described. The rostro-palatine ligament is also well-developed and has the usual relations, but, because of the shortening and deepening of the snout, it lies in a nearly horizontal position, the position being the more nearly horizontal, the smaller the specimen. The tendon of that part of the adductor mandibulae muscle that has its insertion on the maxillary in the other fishes of the group, is here also well developed, and, the posterior portion of the ligamentary process of the maxillary not being developed, is inserted on the dorsal surface of the body of the bone near its proximal end. The naso-maxillary ligament is a short stout ligament that extends from the lachrymo-palatine process of the nasal to the outer end of the ascending process of the maxillary. The vomero-palatine and lachrymo-palatine ligaments are reduced, because of the articulating contact of the parts concerned, to tough fibrous or ligamentous tissues that hold the articulating surfaces together. No other definite ligaments were recognised in the dissections, but in the sections of the small specimens there is a well developed ligament that extends from the lateral surface of the rostral to the dorsal end of the ascending process of the maxillary; and another that extends from the ventral (here posterior) edge of the ascending process of the premaxillary to the proximal end of the maxillary, this ligament traversing the narrow space between the rostral and the articular process of the premaxillary.

The VOMER differs somewhat from the bone in the other fishes of the group, and it can be best understood by stating, at once, that this part of the skull of Dactylopterus has been so greatly flattened that the ascending processes of the vomer have apparently been pressed down upon and become completely fused with the underlying body and lateral processes of the bone; the antorbital cartilage being, so to speak, squeezed out from between the dorsal and ventral limbs of the bone. As a result of this, the vomer is a solid bone of the shape shown in the figures, with a convex ventral and a concave dorsal surface, the exposed portion of the latter surface being about two-thirds as long as the ventral surface of the bone, and representing the ascending processes of the bone. This part of the dorsal surface of the bone forms the floor of the anterior portion of the rostral chamber, is grooved in the middle line to receive the rod-like prenasal process of the antorbital cartilage, and, lateral to that groove, on either side, has a slightly raised and flattened surface which gives articulation to the ascending process of the corresponding maxillary. The middle portion of the hind edge of this part of the vomer abuts against the anterior edge of the antorbital cartilage, but whether it is in synchondrosis with that cartilage or not, could not be definitely determined. Apparently it is not, the vomer of Dactylopterus seeming to be a purely dermo-membrane bone, and not appreciably overlapping or having perichondrial relations to the dorsal surface of the adjacent cartilage. Lateral to the antorbital cartilage, on either side, the thin hind edge of this part of the vomer — here apparently formed by the fusion of the lateral and ascending processes — suturates with the pedicle of the corresponding ectethmoid, the hind end of the short body of the bone underlying the antorbital cartilage and suturating with the parasphenoid.

The head of the vomer is bent downward and thickened, as in the other fishes of the group, this thickened portion forming a broad transverse but untoothed surface which extends across the anterior end of the ventral surface of the bone. The lateral ends of this dental but untoothed ridge are concave or flattened, and give origin, on either side, to a very short but stout vomero-palatine ligament which has its insertion on the internal surface of the anterior end of the body of the palatine. Beginning immediately lateral to the dental ridge, at the anterior edge of the vomer, a slight ledge extends postero-laterally across the ventral surface of the bone to its hind edge, and that small part of the ventral surface of the bone that lies antero-lateral to this ledge lies at a slightly deeper level than the remainder of the surface. The anterior edge of this little surface of the bone is rounded, fits into a deep groove on the internal surface of the base of the maxillary process of the palatine, and gives articulation to that bone; the tall posterior wall of the groove on the palatine fitting against the little depressed surface on the vomer and the edge of this part of the groove abutting against the ledge on the vomer and so limiting the inward swing of the palato-quadrate apparatus. The rounded articular edge of the vomer is continuous with a similar edge on the pedicle of the ectethmoid, the latter bone apparently participating slightly in the articulation; this articulation thus certainly containing the anterior ethmo-palatine articulation of the other fishes of the group, and apparently representing that articulation alone. Posterior to the articular groove on the palatine, the dorsal edge of the latter bone abuts against the ventral surface of the pedicle of the ectethmoid and is bound to it by tough fibrous tissue, this contact apparently representing the posterior ethmo-palatine articulation, here practically suppressed.

The ECTETHMOID has a somewhat diamond-shaped and strongly convex external surface, the dorsal and lateral surfaces of the bone being inclined at more than a right angle to each other, and the lateral edge of the bone being, in consequence, directed ventro-mesio-posteriorly. The posterior edge of the bone is curved and slightly concave, is presented postero-laterally, and forms the anterior portion of the margin of the orbit. The mesial edge of the bone forms two sides of the diamond-shaped outline of the bone. The posterior one of these two sides is straight, is presented postero-mesially and suturates with the frontal; the anterior one suturating in its posterior half with the nasal, while its anterior half is occupied by a deep, oblong incisure which forms the ventro-antero-lateral boundary, and part of the dorso-postero-mesial boundary of the nasal opening. The bent-under lateral edge of the bone is slightly concave, the concavity arching over the lateral edge of a tall and flat articular eminence which begins at this edge of the ectethmoid and extends mesially and slightly posteriorly along the ventral surface of the bone. This eminence projects ventro-mesially and gives articulation to a facet on the dorsal edge of the lachrymal.

Beneath the curved external, and evidently purely dermal portion of the ectethmoid, the deeper portion of the bone extends into the cartilage of the antorbital process, forming a sort of pedicle to the external portion. The pedicle is directed ventro-mesially, and is partly in synchondrosis with the median remnant of the antorbital cartilage, and partly in sutural contact with the vomer and parasphenoid. The anterior surface of the pedicle is deeply hollowed to form part of the bounding wall of the nasal pit, its posterior surface being less deeply hollowed to form part of the anterior wall of the orbit. In the mesial edge of the pedicle there is an incisure which, with the adjoining cartilage, forms a foramen which transmits the olfactory nerve from the orbit to the nasal pit.

The ORBIT is deep and low, with curved but nearly transverse anterior and posterior walls, formed, as usual, by the concave posterior surface of the ectethmoid and the anterior surface of the

brain case. The latter surface inclines slightly forward, but lies, as just above stated, in a nearly transverse position. It is formed, as usual, by the proötic, alisphenoid and sphenotic, but the latter bone is reduced and forms only the small dorso-lateral corner of the wall. The wide roof of the orbit is formed mainly by the frontal but partly also by the ectethmoid and sphenotic. Its floor is formed in part by the expanded base of the pedicle of the ectethmoid, in part by the wide parasphenoid, and in part also by the large orbital shelf of the second bone of the infraorbital series.

The interorbital wall is relatively thick. It is single in its ventral but double in its dorsal portion, this latter portion enclosing an anterior prolongation of the cranial cavity, which extends the full length of the interorbital region and lodges the olfactory nerves. The anterior half, approximately, of the wall is cartilaginous, and here the olfactory prolongation of the cranial cavity is roofed by a wide flat band of cartilage, already referred to when describing the rostral chamber. The posterior half of the wall is formed, in its ventral portion, by a median interorbital process of the parasphenoid, and in its dorsal portion by the alisphenoid of either side, the expanded dorsal edges of the latter bones not quite touching in the median line and so leaving a narrow longitudinal opening in the roof of this part of the olfactory extension of the cranial cavity. A ventral flange to the frontal, found more or less developed in all the other fishes of the group is here wholly wanting.

The cartilaginous portion of the interorbital wall is perforated, close to its antero-dorsal corner, by a large oval opening which leads from orbit to orbit and is closed, in the recent state, by membrane. This membrane is single in its ventral but double in its dorsal portion, the latter portion enclosing the anterior end of the olfactory prolongation of the cranial cavity, which prolongation extends to the hind surface of the short pillar of cartilage that forms the hind wall of the rostral chamber. The membrane is pierced, on either side, by the olfactory nerve, that nerve then traversing the extreme anterior end of the orbit to enter and traverse the opening that leads from the orbit into the nasal pit, that pit being, as already stated, confluent with the rostral chamber. From the single, ventral portion of the membrane, ventral to the olfactory nerves, the obliqui muscles have their origins.

The median interorbital process of the parasphenoid, above referred to, is a tall broad Y-shaped process, the spreading arms of which may be said to present three regions. In the anterior region each arm is formed by a thin plate of bone which overlaps externally the anterior edge of the corresponding alisphenoid, and, anterior to that bone, lies against the external surface of a part of the cartilage that encloses the interorbital extension of the cranial cavity. In the middle region, the dorsal edge of either arm is thickened and suturates with the ventral edge of the corresponding alisphenoid. In this region the dorsal surface of the process seems to form the floor of the interorbital extension of the cranial cavity, but there may here have been delicate lining plates of cartilage that were lost in dissection. The basal portions of the arms of the Y are connected, at the hind edge of this middle region, by a delicate transverse web of bone. In the posterior region, the arms of the Y are short and spread considerably, thus forming, on the dorsal edge of this part of the process, a basin-like depression in which the optic chiasma rests. The alisphenoid of either side arches above this optic depression of the process of the parasphenoid and, anterior to it, suturates, as already stated, with the corresponding dorsal edge of the olfactory portion of the process. The posterior corner of each arm of the Y is prolonged and terminates in a point directed toward, or even reaching the dorsal edge of the orbital surface of the proötic. A large fenestration of the interorbital wall is thus here formed which may be wholly enclosed by the bounding bones, those bones being the alisphenoids and proötics of either side and the median interorbital process of the parasphenoid. The

fenestration, in the prepared skull, leads from orbit to orbit, traversing the interorbital portion of the cranial cavity. In the recent state, the fenestra of either side is closed by a membrane which is pierced by the optic nerve as it passes from the cranial cavity to the orbit. The two fenestrae are accordingly the optic fenestrae.

The interorbital process of the parasphenoid of Dactylopterus would seem to be the homologue of the median process of the same bone of Gymnarchus, as shown in Erdl's ('47) figures, which process is considered by that author as the lower portion of the ala magna, and by Ridewood ('04b, p. 198) as the basisphenoid. It seems also to be the equivalent of the basisphenoid of Ameiurus ('Mc Murrich, '84), fused, perhaps, with the orbitosphenoid of that fish. It is apparently the homologue of the median process of the parasphenoid of Peristedion, but enormously developed. That it contains an originally independent basisphenoid element, as its general relations would certainly indicate, seems improbable, for even in 5 cm specimens there is no slightest indication of two independent ossifications. In these latter specimens, the process is apparently wholly of membrane bone, but it is in part formed by two thin laminae of bone which enclose between them a part of the cartilage of the interorbital septum, much as the pedicle of the basisphenoid does in young specimens of Scorpaena.

Ventral to the optic fenestra, and, in most of my specimens, partly confluent with it, there is a second large perforation of the posterior portion of the interorbital wall, this perforation also leading from orbit to orbit but not traversing any portion of the cranial cavity. This perforation is bounded anteriorly by the hind edge of the interorbital process of the parasphenoid. Ventro-posteriorly it is bounded by a tall and thin ridge of bone which extends transversely across the dorsal surface of the parasphenoid between the small and pointed ascending processes of that bone. This ridge of bone projects dorso-posteriorly, suturates on either side with the anterior edge of the ventral portion of the proötic and slightly also with the ventral edge of the orbital portion of that bone, but between the two proötics presents a free dorsal edge. In the recent state, a membrane extends from this free portion of the edge of the ridge upward and forward to the concave hind edge of the spreading arms of the orbital portion of the interorbital process of the parasphenoid, the lateral edges of the membrane, postero-ventral to those arms, being attached, on either side, to the mesial edge of the nearly vertical orbital portion of the corresponding proötic. Against that part of this membrane that lies between the orbital portions of the proötics, or immediately postero-ventral to it, lies the pituitary body, the entire opening closed by the membrane, or at least that part of it that lies between the proötics, accordingly being the pituitary opening of the brain case. The whole opening may be referred to as that opening.

The ventral one of the two usually confluent perforations of the interorbital wall of Dactylopterus thus lies between a membrane that fills the pituitary opening of the brain case and a process of the parasphenoid the dorsal end of which fulfils the function of a basisphenoid, if it be not in part that bone. On the antero-dorsal portion of the osseous boundary of this ventral perforation of the interorbital wall, and partly also on the ventral surface of the membrane that closes the pituitary opening, a median vertical membrane has its attachment. Ventro-posteriorly this membrane becomes less strong, and separates into two parts which spread to either side and are doubtless attached to the parasphenoid, though this could not be satisfactorily determined in my material. The membrane is thus a median vertical one which closes, more or less completely, the ventral perforation. On the dorsal portion of this membrane, in 5 cm specimens, and directly opposite its fellow of the opposite

side, the rectus externus muscle has its origin. Ventro-anterior to the rectus externus, and also wholly on the membrane, the rectus internus has its origin. The rectus inferior runs upward and backward lateral to the rectus internus, and has its origin in part on the posterior portion of the membrane that closes the optic fenestra and in part on the adjoining and bounding portions of the interorbital process of the parasphenoid. The rectus superior runs downward posterior to the rectus inferior, anterior to the rectus externus, and lateral to the rectus internus, and has its origin on the dorsal surface of the parasphenoid. The pituitary vein forms a transverse commissure across the dorsal surfaces on the recti interni, and, on either side, runs dorso-posteriorly to join the jugular vein as that vein enters the trigemino-facialis chamber. The internal carotid artery traverses a canal that lies wholly in the parasphenoid, traversing that bone from its ventral surface to issue on the dorsal surface in the region of the ventral perforation of the interorbital wall. There it gives off the orbito-nasal artery, and, joining its fellow of the opposite side, passes upward in the middle line, between the recti interni and immediately anterior to the transverse commissure of the pituitary veins, and, piercing the membranous floor of the cranial cavity, enters that cavity. Immediately anterior to the communicating branch to the internal carotid, the afferent pseudobranchial artery communicates with its fellow of the opposite side by a cross-commissural branch which traverses the ventral perforation of the interorbital wall.

The ventral perforation of the interorbital wall of Dactylopterus, and some indeterminate but adjoining portion of the hind end of the orbit, is thus a myodome strictly comparable to that of the other fishes of the group, but it is so short, antero-posteriorly, that it appears transverse instead of longitudinal in position. In Scorpaena the myodome extends almost to the hind end of the basioccipital. In Peristedion it has been considerably shortened, and extends, as it does in Amia, only to the hind edges of the proötics. In Dactylopterus, it has been still further shortened, and, as a result of this shortening, some portion of the proötic bridge has been tilted upward so that it lies in a nearly vertical transverse position and forms an apparent part of the hind wall of the orbit; the myodome being, so to speak, squeezed or shoved out of the brain case into the hind end of the orbit.

The PARASPHENOID is a broad flat bone the principal features of which have just above been described in describing the orbit. It suturates anteriorly with the vomer and ectethmoids, posteriorly with the basioccipital, and laterally, in its posterior portion, with the proötics. Dorsally it is in sutural contact, by its interorbital process, with the alisphenoids. Its ascending process, on either side, is a small pointed process which suturates with the ventral end of the sharp angle that separates the lateral and orbital surfaces of the proötic. On the dorsal surface of the bone, between these processes, there is a transverse ridge, already described, and posterior to this ridge the dorsal surface of the bone is flat and smooth, without the median longitudinal ridge usually here found on the bone. This seems to indicate, as will be more fully discussed below, that the transverse ridge represents the longitudinal ridge usually found in other fishes, but here greatly shortened. The ridge is tall and thin and inclines upward and backward, and on its posterior surface, in the median line, there is a large pit-like depression. The internal carotid foramina perforate the bone, instead of lying between it and the proötics.

The BASISPHENOID is either wanting or is indistinguishably fused with the interorbital process of the parasphenoid.

The ALISPHENOID, as seen from the outside of the skull, is a sub-semicircular bone, the curved edge directed ventrally and deeply notched to form the superior border of the optic fenestra. Immediately anterior to this fenestra, the ventral edge of the bone suturates with the dorsal edge of the middle region of the interorbital process of the parasphenoid, while anterior to that region of sutural contact it is in synchondrosis with the cartilage of the interorbital wall. Posterior to the optic fenestra it suturates with the proötic, the hind corner of the bone being in synchondrosis with a small interspace of cartilage that lies between it and the proötic and sphenotic. On the internal surface of the bone there is, as in the other fishes of the group, a large brace-like process which separates the mid-brain and fore-brain recesses of the cranial cavity. The dorsal edge of this process is greatly expanded, as is also the dorsal edge of the bone itself, the large flat surface thus formed giving support mainly to the frontal; but the hind corner of the brace-like process extends backward beneath the anterior edge of the supraoccipital and so gives support to that bone also.

The alisphenoid is perforated, in the adult, immediately posterior to the optic fenestra, by a small foramen which doubtless transmits the nervus trochlearis; that nerve traversing the optic fenestra, close against the alisphenoid, in 5 cm specimens. Near its dorsal edge the bone is traversed by a small canal which transmits a branch of the orbito-nasal vein, accompanied by a general cutaneous branch from the r. oticus trigemini. The bone is not traversed, as it is in the other fishes, by the lateralis branch that innervates the terminal organ of the supraorbital canal, that branch passing upward external to the alisphenoid and then perforating the frontal.

The SPHENOTIC is a small and irregular bone and is, in all my specimens, inseparably ankylosed with the postfrontal, which latter bone lies upon and occupies about one half of the dorsal surface of the sphenotic. The remainder of the dorsal surface of the sphenotic gives support mainly to the pterotic, a small corner only of the bone supporting the hind edge of the frontal. In the fusion of the sphenotic with the postfrontal, Dactylopterus resembles Polypterus, which latter fish is the only other one in which, as I have stated in a recent work ('04, p. 56), I know this fusion to be of regular occurrence. Ridewood, since the publication of that work, has said ('04a, p. 56) that the fusion of these two bones is also of almost constant occurrence in Amia, their separation in that fish, being an „occasional feature only". While this may be true of alcoholic or otherwise preserved specimens, it certainly is not of fresh material.

The sphenotic is in sutural contact with the proötic and pterotic but not with the alisphenoid, being separated from the latter bone by a small interspace of cartilage. On the lateral edge of the bone there is a stout process which gives articulation to one of four articular processes on the dorsal end of the hyomandibular, the particular process here concerned apparently being the regular anterior articular head of the hyomandibular, as will be later explained. Immediately dorsal to this articulating process there is, on the same edge of the sphenotic, a sharp process which gives support, on its lateral surface, to the small postorbital bone; probably also giving insertion to a part of the levator arcus palatini muscle, though this was not investigated.

Between the sphenotic and pterotic there is a large and deep dilatator fossa, roofed by the pterotic and sphenotic, the postfrontal apparently not coming into roofing relations with it. The anterior wall of the fossa is perforated by a large foramen which transmits the ramus oticus.

The PROÖTIC is a large bone with orbital and lateral portions, these two portions being separated from each other by a tall and ridge-like edge which, because of the flattened condition

of the head, lies in a nearly horizontal position directed postero-laterally and but slightly upward. This ridge-like postorbital edge is perforated by a large opening which represents the trigemino-facialis chamber, and from this chamber five foramina lead into the cranial cavity. One of these foramina transmits the truncus ciliaris profundi accompanied by the encephalic branch of the jugular vein; a second one transmits the ramus ophthalmicus lateralis; a third the truncus trigeminus and related lateralis nerves, and a fourth the truncus facialis. The fifth foramen certainly transmits the nervus abducens, and probably that nerve alone, the palatinus facialis doubtless traversing the facialis foramen, but these nerves were not traced in the adult. In 5 cm specimens, they both traverse the ventral portion of the facialis foramen, enter the trigemino-facialis chamber, and traversing that chamber, issue through its trigeminus opening. The chamber is also traversed, as usual, by the jugular vein and the truncus sympatheticus.

Dorsal to the trigemino-facialis chamber, the tall postorbital edge of the proötic expands abruptly and bears, on this expanded portion, an elongated and curved articular surface the axis of which is directed dorso-posteriorly while the surface itself is directed laterally. This surface gives sliding articulation to a curved surface on the anterior one of the four articular heads of the hyomandibular. Slightly dorsal (here lateral) to this articular surface the bone is connected by synchondrosis with the sphenotic.

The orbital portion of the proötic is large, is transverse and nearly vertical in position, inclining upward and slightly forward, and arises from the internal surface of the lateral portion of the bone slightly posterior to its anterior edge. Near its dorsal edge it is perforated by the oculomotorius foramen. Its mesial edge does not reach the middle line, a small ventral portion of the edge suturating with the transverse ridge on the dorsal surface of the parasphenoid, while the dorsal portion of the edge is free and forms part of the boundary of the pituitary opening. The lateral portion of the bone has its ventro-mesial edge bevelled on its outer surface, and there suturates with the lateral edge of the parasphenoid. Internal to this line of sutural contact, and posterior to the orbital portion of the bone, the edge of the proötic is slightly grooved and this groove lodges the lateral edge of a broad band of cartilage which extends across the middle line to the corresponding edge of the proötic of the opposite side. The hind edge of the band is lodged in a groove on the anterior edge of the basioccipital, its anterior edge reaching to the posterior surface of the transverse ridge on the dorsal surface of the parasphenoid. This anterior edge of the cartilage seems not to be a free edge, but to rather abruptly but insensibly pass into a delicate membrane which is connected, anteriorly, with the stouter membrane that fills the pituitary opening of the brain case. Two suppositions are accordingly possible to explain the conditions here; either the postpituitary portion of the proötic bridge has been depressed and appressed upon the underlying ventral flanges of the proötics, as assumed by Gill ('91a, p. 379) in his descriptions of Hemitripterus, or the entire proötic bridge has been shortened and shoved forward nearly to the anterior edges of the ventral flanges of the proötics and there tilted upward to form, on either side, the orbital portion of the corresponding bone. The conditions found in Blennius, to be later described, indicate that the first of these two assumptions is probably the proper one, but they also indicate that the process has not been simply one of depression and appression of the proötic bridge, but also one of reduction of the ventral flanges of the proötics. These ventral flanges have, apparently, been so greatly reduced that they are practically suppressed, and the primary floor of the cranial cavity is here formed by the proötic bridge alone, that bridge lying directly upon the parasphenoid. The hypophysial fenestra is then represented, in its posterior

portion in that long and wide space that lies between those surfaces of the proötics of either side that suturate with the lateral edges of the parasphenoid, while in its anterior portion it is represented in the space that lies between and anterior to the orbital portions of the proötics, this space opening onto the floor of the myodome and being filled by the transverse ridge on the dorsal surface of the parasphenoid. This latter ridge on the parasphenoid is accordingly the greatly shortened and widened homologue of the longitudinal ridge on the bone in the other fishes of the group. A result of this arrangement is that the pituitary opening of the brain case is partly filled, toward the orbit, by the transverse ridge on the parasphenoid, and that the hind end of the pituitary opening is confluent with the hypophysial fenestra at the hind end of that portion of the fenestra that opens onto the floor of the myodome.

The lateral surface of the proötic has dorsal and ventral regions separated by a pronounced but rounded angle which starts from the dorsal edge of the trigemino-facialis chamber and runs postero-mesially to the hind edge of the bone. The dorsal portion of the surface forms the anterior portion of a large subtemporal fossa, described below. On the internal surface of the bone, and parallel with this dorsal portion of its lateral surface, there is a tall flange of bone which projects from below upward and forms the anterior wall of the labyrinth recess. The dorsal edge of this flange is partly capped with cartilage and there gives support to the hind edge of the frontal and to the parietal, the hind edge of the flange projecting postero-mesially beneath the supraoccipital and there being continuous with a slight ridge on the internal surface of that bone. The deep tall space between the flange and the lateral wall of the bone is continued dorso-antero-laterally by a slight recess on the internal surface of the sphenotic, and the large recess thus formed between the two bones lodges not only the anterior semicircular canal and the anterior portion of the utriculus, but probably also the anterior end of the sacculus, for there is no differentiated saccular groove. The recess must also lodge an anterior portion of the external semicircular canal, for that canal leaves the recess near its dorso-antero-lateral corner to enter it own special canal in the pterotic. The exact relations could not be determined because of the want of sufficient material.

Anteriorly the proötic is bounded by, and is partly in synchondrosis and partly in sutural connection with the alisphenoid. Dorsally and posteriorly it is in similar relations with the sphenotic, pterotic, basioccipital and exoccipital. Ventrally it is overlapped externally by and is suturally connected with the parasphenoid.

The PTEROTIC has, more than in the other fishes of the group, the appearance of being formed of two separate and independent components secondarily fused with each other, for, although the two components have the same length, they are not exactly superimposed; the dermal component projecting forward beyond the primary component, and this latter component projecting posteriorly beyond the dermal one. This projecting portion of the primary component supports the anterior edge of the suprascapular.

The dermal component of the bone is bounded, as usual, by the frontal, postfrontal, parietal, lateral extrascapular (rocher) and suprascapular, and the lateral half of this part of the bone is bent abruptly downward, as are also corresponding portions of the postfrontal and suprascapular, a rounded longitudinal angle thus being formed, which extends across the three bones and terminates, at teh hind end of the suprascapular, in a strong spine. This component of the pterotic is thus an angular bone placed longitudinally along the lateral edge of the dorsal surface of the skull. It is traversed by the main infraorbital latero-sensory canal and lodges three sense organs of that line, two innervated

by the oticus lateralis and one by the supratemporalis lateralis vagi. Near the middle of the bone, between the organs innervated by the oticus and supratemporalis lateralis vagi, the main infraorbital canal anastomoses with the dorsal end of the preopercular canal.

The primary component of the pterotic has a thickened anterior portion but is elsewhere a thin plate of bone which lines the ventral surface of the angular dermal component of the bone. It is traversed by the external semicircular canal, but otherwise has no bounding relations to the cranial cavity. This is due to the presence of a large and deep depression on the lateral surface of the brain case, this depression pinching the skull, so to speak, to such an extent that the primary component of the pterotic has been pressed upward against the under surface of its dermal component, has ceased to form part of the apparent lateral surface of the brain case, and simply lines the ventral and ventro-mesial surfaces of the overhanging roof of the depression. This depression includes both the proötic and subtemporal fossae of Scorpaena, and it has, in addition, a large posterior extension which lies posterior to the arch of the external semicircular canal and is not found in Scorpaena. The entire depression may, however, be called the subtemporal fossa, the fossae of opposite sides giving to the brain case, in ventral views, an hour-glass-shaped appearance. The adductores hyomandibularis and operculi have their origins in the fossa, arising mainly on a band of cartilage that separates the pterotic from the exoccipital. The levators of the first four branchial arches have their origins in the anterior portion of the fossa, anterior to the adductor hyomandibularis, while the fifth levator muscle has its origin ventro-mesial to the adductor operculi, between that muscle and the foramina for the vagus and glossopharyngeus. This fifth levator perforates, to reach its surface of origin, a mass of tissue that looks like degenerate glandular tissue and that must be the homologue of what I considered as the thymus in Amia ('97, p. 643). Whatever it may be, this tissue fills the entire fossa ventro-mesial and posterior to the adductores hyomandibularis and operculi, and the fossa would seem to be developed in some relation to it rather than as any consequence of the origins of the several muscles here.

On the anterior edge of the thickened anterior portion of the primary component of the pterotic there are two fossae, the larger, mesial one lying on the internal surface of the bone while the smaller, lateral one lies on its external surface. The mesial fossa lodges the anterior portion of the external semicircular canal, and is in communication with the dorso-antero-lateral end of the tall recess already described on the internal surface of the proötic and sphenotic; the posterior portion of the semicircular canal traversing the thin posterior portion of the auto-pterotic, and forming a prominent ridge on its external surface. The lateral one of the two fossae forms the posterior half of the dilatator fossa, the anterior half of that fossa lying in the sphenotic. Immediately posterior to the dilatator fossa, and so placed that it seems to form part of the mouth of that fossa, there is, on the external surface of the auto-pterotic, a large round articular fossa which gives articulation to the regular posterior articular head of the hyomandibular. The hind edge of this articular fossa is thickened and grooved to form an elongated, transversely placed and slightly convex articular surface, which gives a sliding articulation to the posterior one of the four articular heads of the hyomandibular. Immediately dorso-lateral to this articular surface is the perforation by which the preopercular latero-sensory canal joins the main infraorbital canal.

The auto-pterotic is bounded anteriorly by the sphenotic and proötic, and also by a small interspace of cartilage between the adjoining edges of those two bones. It is separated from the exoccipital by a band of cartilage, and beneath (dorsal to) this band it is in contact with the lateral

edge of the epiotic. The hind end of the bone gives support, as already stated, to the anterior end of the suprascapular.

The pterotic of Dactylopterus thus has no exposed surface corresponding to the one that forms part of the lateral bounding wall of the temporal fossa in the other fishes of the group. That portion of the temporal fossa that is usually bounded by this bone is thus either wholly absent in Dactylopterus, or it has been reduced, by the compressive action that has given rise to the subtemporal fossa, to a narrow space that lies between the pterotic-exoccipital band of cartilage, just above referred to, and the overlying dermal bones on the dorsal surface of the skull. The band of cartilage is evidently the homologue of the cartilage that forms the bottom of the temporal fossa in the other fishes, and as this cartilage is certainly not in synchondrosis with the overlying dermal bones, a thin space must exist between them, in the place where the temporal fossa is usually found. A further possibility regarding a portion of the fossa will be referred to when describing the suprascapular.

The BASIOCCIPITAL is broad and thin, is slightly convex on its internal and slightly concave on its external surface, and the median longitudinal line on its ventral surface presents a slight reëntrant angle. On the hind end of the bone there is a deep median pit which extends forward to the line of the reëntrant angle and represents the vertebral depression on the hind end of the bone. Lateral to this pit, the wide flange-like portions of the bone give support, on their dorsal surfaces, to the ventral edges of the exoccipitals. Anteriorly the bone suturates with the proötics and parasphenoid. A very slight depression on either side of the internal surface of the bone forms the hind end of the saccular groove. Between these two depressions there is, in the anterior portion of the bone, a slight median depression, the significance of which could not be determined in my limited material. The anterior edge of the bone is grooved, and encloses the hind end of the thin median sheet of cartilage that connects the ventral edges of the proötics of opposite sides. The median portion of the hind edge of the dorsal surface of the bone forms the ventral boundary of the foramen magnum.

The EXOCCIPITAL has a concave lateral and a strongly reëntrant posterior surface. The latter surface has the two usual portions, one of which forms part of the hind wall of the cranial cavity while the other arches over the medulla, the two portions appearing, in the disarticulated bone as a stout, tall, V-shaped ridge arising from the dorso-mesial surface of a sub-oval bone. That part of the posterior portion of the bone that arches over the medulla has a thick dorso-mesial edge, which suturates in part with its fellow of the opposite side but mainly with the ventral edge of the spina occipitalis. The dorsal edge of that part of the bone that forms part of the hind wall of the cranial cavity suturates with the ventral edge of a strong ridge on the ventral surface of the epiotic, this ridge forming the posterior surface of the latter bone. Slightly antero-lateral to this ridge on the epiotic, a relatively large V-shaped portion of the ventral surface of that bone is in sutural contact with a corresponding surface on the dorso-mesial surface of the lateral plate of the exoccipital; this latter surface of contact extending downward from the dorsal edge of the exoccipital nearly to the central point of the bone. Between the portions of these two bones that have these two sutural connections — the lateral and posterior plates of the exoccipital, below, and the epiotic above — there is a tall and narrow space which must lodge the posterior portion of the external semicircular canal, the larger portion of the posterior canal, and possibly also the hind end of the utriculus; but want of material prevented my determining the exact relations. A broad, low and rounded ridge

on the outer surface of the exoccipital marks the position of the dorso-lateral portion of this labyrinth space, and forms a continuation of the ridge on the pterotic that marks the course of the external semicircular canal in that bone.

The dorsal edge of the exoccipital reaches the ventral surface of the overhanging roof of the skull and is there separated by a relatively wide band of cartilage from the ventral edge of the pterotic, that edge of the latter bone here being presented mesially. This band of cartilage forms a nearly longitudinal line along the bottom (roof) of the subtemporal fossa, and lies against the ventral surfaces of the parietal and lateral extrascapular.

On the hind edge of the lateral plate of the exoccipital there are two flat stout processes separated by a deep and rounded incisure. The dorso-lateral process suturates with the pedicle of the suprascapular, the ventro-mesial one suturating with, instead of articulating with, a process on the anterior edge of the first vertebra. Antero-internal to the incisure between the bases of the two processes, a canal traverses the medullary plate of the bone, transmitting the occipital nerve or nerves. Ventrally the exoccipital suturates with the basioccipital, in the manner already explained. On the lateral surface of the bone there is a small foramen which doubtless transmits the nervus glossopharyngeus, and posterior to that foramen there is a large pit, in the bottom of which there are two to four foramina which open into the cranial cavity and doubtless transmit the nervus vagus alone; the actual relations of these nerves to the bone not being determined for the reasons already given.

The EPIOTIC is a small bone that seems at first sight to bear no resemblance whatever to the pyramidal bone of the other fishes of the group. The dorsal surface of the bone is flat and sub-oval in shape, and on the ventral surface of this thin dorsal plate there are two relatively tall and thin flanges. One of these flanges is straight and extends from about the middle of the mesial edge of bone, postero-laterally to its lateral edge, the ventral edge of the flange suturating with the posterior plate of the exoccipital. The postero-mesial surface of this flange is exposed externally, and forms a surface strictly comparable to the postero-mesial surface of the bone in the other fishes of the group. The second flange lies anterior to the first one and is strongly curved, the hollow of the curve directed forward and both ends of the flange reaching the antero-lateral edge of the bone and there vanishing. The space enclosed within the curve of this flange is roughened and suturates with the dorso-mesial surface of the lateral plate of the exoccipital, as already stated. This roughened surface of the epiotic thus corresponds to the ventral edge of that surface of the bone in the other fishes that forms part of the mesial wall of the temporal groove. The temporal-groove surface of the bone of Dactylopterus is accordingly wholly wanting, or at most is only represented in a part of the thin lateral edge of the bone, this edge being covered laterally and ventrally by the band of cartilage already described between the pterotic and exoccipital.

Between the two flanges on the ventral surface of the epiotic there is a space which forms the dorsal portion of that part of the labyrinth recess which, as just above explained, must lodge the posterior semicircular canal and the posterior portion of the external canal. The dorso-postero-lateral portion of this labyrinth space is bounded externally here ventrally by the band of cartilage between the pterotic and exoccipital; temporal and posterior surfaces of the epiotic not here uniting to form an angle which encloses the summit of the posterior canal, as in the other fishes. The large flat dorsal surface of the epiotic gives support to adjoining portions of the parietal, lateral extrascapular and mesial extrascapular, and its mesial edge is in sutural contact with the lateral edge

of the supraoccipital. The thin plate that forms this part of the bone projects posteriorly beyond the flange that forms the posterior surface of the bone, the two plates forming part of the roof and part of the bottom (antero-lateral corner) of a large fossa on the posterior surface of the skull. The postero-lateral end of the flange that forms the posterior surface of the bone, and adjoining portions of the lateral edge of the bone, suturate respectively with the pedicle and body of the suprascapular.

The SUPRAOCCIPITAL, the interparietal of Cuvier and Valenciennes' descriptions, has the usual dorsal and ventral limbs, and a large spina occipitalis. The dorsal limb of the bone, with the exception of two small lateral processes on either side, comes everywhere to the outer level of the dorsal surface of the skull, and has surface markings exactly similar to those on the adjoining dermal bones; and this apparently dermal portion of this limb of the bone extends posteriorly slightly beyond the line of origin of the ventral limb, onto the dorsal surface of a dorsal plate-like portion of the spina occipitalis. This limb of the bone suturates anteriorly with the frontals, laterally with the parietals, and posteriorly with the mesial extrascapulars; its anterior edge resting, on either side, upon the hind end of the expanded dorsal surface of the brace-like ridge on the internal surface of the alisphenoid. On the ventral surface of the dorsal limb, beginning immediately anterior to the line of origin of the ventral limb, there is, on either side, a small ridge which, extending antero-laterally is continuous with that tall ridge on the internal surface of the proötic that forms the anterior wall of the labyrinth recess. The antero-lateral end of this ridge on the supraoccipital forms one of the two lateral processes on either side of the dorsal limb of the bone, the other process lying immediately posterior and parallel to it, giving support on its dorsal surface to the parietal, and being in synchondrosis, by its postero-lateral edge, with the antero-mesial edge of the epiotic.

The ventral limb of the supraoccipital is irregular, as shown in the figures, and has on either side a strongly concave dorsal and convex ventral surface. Along the median line of the limb a thin median vertical plate of bone arises supported on either side by a similar but slightly inclined plate, these three plates forming the vertical portion of the spina occipitalis. This vertical portion of the spina supports, on its dorsal edge, a flat broad thin plate which forms a direct posterior extension of the dorsal limb of the bone, and gives support, on either side of its dorsal surface, to the corresponding mesial extrascapular. The lateral edge of the anterior end of this flat portion of the spina, on either side, rests upon and is coalesced with the dorsal edge of the lateral portion of the ventral limb of the bone, a deep pocket thus being formed on either side of the posterior surface of the bone, this pocket forming the dorso-mesial corner of a large fossa on either side of the hind end of the skull. The posterior half of the ventral surface of the ventral limb of the bone rests, on either side, on the dorsal edge of the medullary plate of the corresponding exoccipital, either suturating or being in synchondrosis with that bone. Lateral to the exoccipital, the ventral limb of the supraoccipital is in similar contact with the mesial edge of the epiotic.

There is no separate OPISTHOTIC bone, nor is there any indication of the fusion of this bone with any of the other bones.

The primary bones, and their relations to the dorsal surface of the primary skull, now having been described, the dermal bones that overlie them and form the casque-like dorsal surface of the skull can be described.

The two NASALS have fused in the median line to form a single median bone, and have already been described.

The FRONTAL is an eight-sided bone, each side being straight or slightly concave. One of these sides forms the middle portion of the dorsal margin of the orbit, another suturates with the frontal of the opposite side, the others suturating with the ectethmoid, nasal, supraoccipital, parietal, pterotic and postfrontal. The bone has no ventral flange. It rests upon the expanded dorsal edges of the body and brace-like internal process of the alisphenoid, on a small portion of the sphenotic, and on a small projecting shelf from the deeper layers of the anterior edge of the supraoccipital. It is traversed by the supraorbital latero-sensory canal and lodges five organs of the line, as will be later fully described.

The POSTFRONTAL is a small dermal bone that lies upon and is inseparably fused, in all of my adult specimens, with a lateral portion of the dorsal surface of the sphenotic. It suturates with the frontal and dermo-pterotic, and is traversed by the main infraorbital latero-sensory canal, lodging one organ of that canal, innervated by the oticus lateralis.

The PARIETAL is a sub-oval bone, bounded anteriorly by the frontal, laterally by the pterotic, posteriorly by the lateral and mesial extrascapulars, and mesially by the supraoccipital. It rests upon the dorsal surface of the epiotic, upon the dorsal edges of those flanges of the proötic and supraoccipital that form the antero-mesial wall of the labyrinth recess, and also upon a small shelf projecting mesially from what are apparently the deeper layers of the dermal portion of the pterotic.

The LATERAL EXTRASCAPULAR is a small oval bone traversed by the lateral portion of the supratemporal commissure of the latero-sensory canals, and lodging one organ of that canal. It is not traversed by the main infraorbital canal, but a groove on its lateral edge lodges a short section of that canal, apparently without related organ, as will be further explained when describing the canals. It is bounded antero-mesially by the parietal, antero-laterally by the pterotic, postero-laterally by the suprascapular, and postero-mesially by the mesial extrascapular. It has no bounding relations either to the subtemporal fossa or to the large fossa on the posterior surface of the skull, its ventral surface being entirely covered by the epiotic, pterotic and suprascapular, on which bones it rests.

The MESIAL EXTRASCAPULAR is a large subrectangular bone with straight and nearly parallel lateral and mesial edges. It is traversed by the mesial section of the supratemporal commissure and lodges one organ of that commissure. It suturates, in the middle line, with its fellow of the opposite side. Anteriorly, it is bounded by the supraoccipital and parietal, and laterally by the lateral extrascapular and suprascapular. Its mesial third, approximately, lies upon the broad flat dorsal surface of the spina occipitalis, its lateral third resting upon a shelf-like portion of the mesial edge of the suprascapular. Between those two bones it forms part of the roof of the large fossa on the corresponding side of the posterior surface of the skull.

The SUPRASCAPULAR is a large bone with a prolonged and pointed hind end. It is bounded anteriorly by the pterotic, antero-mesially by the lateral extrascapular, and mesially, along the anterior half only of its length, by the mesial extrascapular. The lateral half of the bone is bent downward at an angle to the mesial portion, as already stated, and along this angle there is a stout ridge which begins at the anterior quarter of the bone and extends backward to its pointed hind end. The bone is traversed by the main infraorbital latero-sensory canal and lodges one organ of that line, innervated by a branch of the supratemporalis lateralis vagi. This organ, in 5 cm specimens, is much

larger than the other organs of the line, and may perhaps represent the two organs usually found one in this bone and the other in the supraclavicular in the other fishes of the group.

On the ventral surface of the bone there is a stout V-shaped flange, projecting ventro-antero-mesially. The line of origin of the anterior limb of the V begins at the rounded antero-mesial corner of the bone, and from there runs postero-laterally until it reaches the angle between the mesial and lateral portions of the bone. There it turns postero-mesially, nearly at a right angle, and so continues until it reaches the mesial edge of the bone at about its middle point. From this right-angled line of origin, the V-shaped flange projects ventro-antero-mesially, its two limbs and the overlying body of the bone enclosing a sub-pyramidal space which forms the lateral, recess-like corner of the large fossa on the hind end of the corresponding half of the skull. The angle of the V-shaped flange is thickened, and its ventral end suturates with the exoccipital, the dorsal portion of the mesial edge of the anterior limb of the flange suturating with the postero-lateral end of that flange on the internal surface of the epiotic that represents the posterior surface of that bone. At the dorso-mesial corner of the anterior surface of the anterior limb of the flange on the suprascapular, there is a small recess which lodges but is not in synchondrosis with the hind end of the band of cartilage that lies between the pterotic and exoccipital. The mesial edge of the suprascapular here closely approaches the lateral edge of the dorsal plate of the epiotic, but apparently does not touch that bone. The V-shaped flange of the suprascapular must accordingly certainly contain the opisthotic process of the bone, and it probably represents both that process and the epiotic process, joined by a web of bone which entirely closes the space usually occupied by the posterior opening of the temporal fossa. However this may be, a posterior opening of a temporal fossa is wholly wanting in this fish, and if any portion of the fossa exists it must open on the lateral surface of the skull and hence be represented in the posterior portion of the large subtemporal fossa. In certain specimens of Cottus octodecimospinosus, I have already shown that the posterior opening of the temporal fossa may be entirely closed by the invading growth of its bounding bones, the fossa then opening wholly on the lateral surface of the skull. In such a fish, if the subtemporal fossa were to be greatly deepened, as it is in Dactylopterus, it would inevitably absorb and incorporate in itself a posterior portion of the adjoining temporal fossa. But in that case the epiotic should form part of the bounding wall of the fossa, and I can not find that it does so in Dactylopterus: the epiotic here apparently being everywhere covered by the hind end of the pterotic-exoccipital band of cartilage which lies in the bottom (roof) of the fossa. The lateral edge of the epiotic, immediately anterior to the pedicle of the suprascapular, comes close to the lateral edge of the pterotic-exoccipital cartilage and may there perhaps be exposed, thus forming part of the bounding wall of the subtemporal fossa. Furthermore, the subtemporal fossa, as defined by Sagemehl, is said to be an excavation of the cranial wall within the arch of the external semi-circular canal, but, in Dactylopterus, the fossa has a large portion which lies posterior to that canal. This posterior extension may therefore represent the posterior portion of the temporal fossa of the fish, here incorporated in the subtemporal fossa by the unusual development of the latter.

On the ventral surface of the suprascapular, close against or even cutting into the lateral edge of the base of the posterior limb of the V-shaped pedicle, there is a deep circular pit, so deep that it shows, on the dorsal surface of the prepared skull, as a circular translucent spot in the bone. This pit gives origin to strong fibrous tissues which have their insertion on the dorsal end of the clavicle, that end of the clavicle not apparently entering the pit, in prepared specimens, but the pit being quite certainly developed in articular relation to it. At the anterior margin of the pit there is a slight

depression which gives articulation to the dorsal end of a long, slender, gutter-shaped and tapering bone, which is applied to the antero-lateral surface of the dorsal end of the clavicle and is certainly the SUPRACLAVICULAR. This bone is not traversed by the main infraorbital canal, and its latero-sensory component must be represented either in a part of the unusually large suprascapular or in a small bone that lies along the postero-lateral edge of the suprascapular and is traversed by the main infraorbital canal after it leaves that bone.

On either side of the hind end of the skull there is a large and deep fossa, already several times referred to. This fossa occupies the entire posterior surface of either side of the skull, and has deep dorso-mesial and dorso-lateral corners, or recesses, and a shallow ventral one. It is bounded by the mesial extrascapular, suprascapular, supraoccipital, epiotic and exoccipital, and there is nothing comparable to it in any of the other fishes of the group. Want of material prevented a proper investigation of it, but it is largely, if not entirely filled by an anterior prolongation of the swim-bladder: the dorsal wall of this portion of the bladder lying close against the ventral surface of the dermal bones that form the roof of the fossa, and the lateral surface of the bladder having closely applied to it a band-like anterior prolongation of the trunk muscles.

2. INFRAORBITAL CHAIN OF BONES.

The infraorbital chain consists of four bones, all of which are traversed by the main infra-orbital canal. In addition to these four bones, there is a small bone, the pontinal of Gill, which extends from the hind edge of the second bone of the series into a reëntrant angle on the anterior edge of the preopercular.

The first infraorbital bone, or lachrymal, has a thickened anterior end which curves mesially, and almost meets, in the middle line, its fellow of the opposite side. The dorsal edge of this part of the bone is slightly grooved and articulates moveably with the antero-ventral edge of the nasal, the dorsal edge of the lachrymal lying upon and being strongly but somewhat loosely bound to the outer surface of the lachrymo-palatine process of the nasal. Internal to the hind end of this grooved portion of the lachrymal, there is, on the internal surface of the bone, a short transverse ridge with a convex outer edge, and slightly posterior to this ridge there is a second but shorter ridge; these two ridges and the groove between them having a sliding articulation with the palatine on the dorso-lateral surface of its maxillary process, as will be later explained. Slightly ventro-posterior to these two articular ridges, a strong brace-like process arises from the internal surface of the lachrymal, projecting dorso-postero-mesially. The dorsal end of this process is large, lies in the level of the dorsal edge of the bone, and has on its dorsal surface a large oval facet which articulates with the lachrymal articular eminence of the ectethmoid. The hind edge of the articular facet suturates with the anterior edge of the orbital shelf of the second infraorbital bone, the hind edge of the lachrymal itself suturating with the second and third infraorbital bones; the second infraorbital lying ventral to the third one and having no bounding relations to the orbit. The bone is traversed by the main infraorbital latero-sensory canal and lodges three sense organs of that line.

The second infraorbital bone is an elongated one, bounded anteriorly by the first and dorsally by the third bone of the series. The main infraorbital canal enters it at its anterior edge, runs horizontally backward in it and then turns upward and forward at an acute angle, to leave the bone on its dorsal margin and enter the third bone of the series; this section of canal lodging two sense

organs. The ventro-posterior corner of the bone is prolonged into a short process which has articular surfaces for articulation with the pontinal.

The pontinal is a small and somewhat elongated bone, which extends from the second infraorbital into a reëntrant angle on the anterior edge of the preopercular, articulating with and being firmly bound to each of these two bones. It does not lodge any part of the latero-sensory canal, and is accordingly either an independent dermal ossicle or a detached portion of the second infraorbital bone.

The third infraorbital bone bears, along the internal surface of its orbital margin, a large thin projecting plate of bone which forms about one half of the floor and a corresponding part of the posterior wall of the orbit. The central portion of this orbital shelf is supported by a bracing web of bone which arises from the internal surface of this bone and is continued beyond it onto the internal surface of the second infraorbital bone, near its hind edge. From the internal surfaces of the adjoining edges of these two infraorbital bones, immediately anterior to the bracing web, a strong ligament arises, and running forward has its insertion on the ventral surface of the dorsal limb of the dentary. The anterior end of the orbital shelf projects forward beyond the anterior edge of the body of the bone, along the inner surface of the first infraorbital, and comes into sutural contact with, and is firmly bound to, the hind edge of the dorsal end of the brace-like articular process of the latter bone. The bone is traversed by the main infraorbital latero-sensory canal and lodges three organs of the line.

The fourth infraorbital is a small bone, postorbital in position, that is in contact ventrally with the third infraorbital and dorsally with the postfrontal. It transmits the latero-sensory canal from the former to the latter bone, lodging one organ of the line.

The first and third infraorbital bones are the preorbital and fourth suborbital, respectively, of Gill's descriptions; and these two bones and the second infraorbital, together, form the first suborbital of Cuvier and Valenciennes' descriptions. The second suborbital of Cuvier and Valenciennes is the third suborbital, or pontinal of Gill's descriptions, but this bone, not being traversed by the infraorbital canal, would seem not to properly be an independent element of the infraorbital series.

3. SUSPENSORIAL APPARATUS AND MANDIBLE.

The bones that form the hyomandibulo-palato-quadrate apparatus are firmly united to form two pieces with a flexible joint between them. The posterior and much larger piece is formed by the preopercular, hyomandibular, symplectic, quadrate and metapterygoid; and the anterior piece by the palatine, the ectopterygoid and the entopterygoid. The flexible joint between the two pieces is nearly transverse to the axis of the body of the fish, and permits that extensive lateral motion of the hind end of the apparatus that easily places the large preopercular spine at an angle of more than 45° to the axis of the body.

The PREOPERCULAR has a horizontal limb, which terminates in the long and well known spine, and a vertical limb which extends antero-dorsally at an angle of about 75° to the horizontal limb. In the angle between the two limbs there is an articular facet, and immediately dorsal to this facet an articular eminence, both of which give articulation to corresponding surfaces on the hind end of the pontinal. The angle between the two limbs is spanned by a large web of bone which arises from the deeper layers of the preopercular; and, external to this web, on either limb of the bone, between the web and the outer surface of the thick, related limb, there is a large V-shaped

groove. The bone is traversed its full length by the preopercular latero-sensory canal, and lodges six sensory organs.

The HYOMANDIBULAR is an irregular bone, roughly triangular in general outline, one of the angles of the triangle being directed dorsally and bearing the articular heads of the bone. Not far from the anterior edge of the triangle, and parallel with it, there is a slightly thickened portion, which represents the shank of the bone. The hind edge of the triangle is slightly convex, and bears on its external surface a tall ridge which projects laterally and slightly anteriorly. The posterior surface of this ridge is applied against, and firmly bound to the antero-mesially presented anterior surface of the dorsal limb of the preopercular, the dorsal end of the latter bone reaching to the lower edge of the opercular process of the hyomandibular. This tall ridge along the hind edge of the hyomandibular of Dactylopterus thus corresponds to the ridge that extends longitudinally along the external surface of the shank of the bone in the other fishes of the group; but here, in Dactylopterus, although the ridge begins on the external surface of the dorsal end of the slightly indicated shank, it extends postero-ventrally at an angle to the shank, and leaves, between itself and the shank, a wide intervening space which is spanned by a thin web of bone. The dorsal end of the ridge is thickened to form a large articular head, which articulates with the facet on the antero-lateral corner of the squamosal, and is accordingly the regular posterior articular head of the bone. Postero-mesial to this articular head there is a stout and bluntly pointed process, directed antero-dorsally in the line of the ridge on the external surface of the bone. The postero-lateral surface of this process is slightly concave, is grooved from its top to its base, and has a sliding articulation with the articular surface on the thickened posterior edge of the articular facet on the squamosal. From the anterior surface of the base of this articular process a strong process is directed antero-ventro-mesially. It expands at its distal end, and has a curved articular edge which is presented mesially and has a sliding articulation with the articular surface on the postorbital edge of the proötic immediately dorsal to the trigemino-facialis chamber. Fused with the lateral edge of the base of this process of the hyomandibular, there is a small process which arises from the anterior surface of the ridge on the external surface of the bone, immediately ventral to the regular posterior articular head. This small process is directed anteriorly and has on its dorsal surface a slightly concave articular surface which articulates with the articular eminence on the sphenotic. This small process accordingly represents the regular anterior articular head of the bone. Each of the two regular articular heads of the hyomandibular of Dactylopterus thus has a related, accessory articular head which has a sliding articulation with the cranium, this arrangement giving great solidity to the joint.

On the hind edge of the bone there is a short opercular process.

On the internal surface of the bone, immediately ventral to the bases of the two accessory articular processes, there is a slight transverse ridge of bone, and on the dorsal surface of this ridge is the internal opening of the facialis canal. This canal traverses the hyomandibular and opens on its external surface immediately posterior to the slightly thickened portion that represents the shank of the bone. Immediately ventral to the transverse ridge, on the internal surface of the bone, a large opening leads directly into the facialis canal, and this opening transmits the ramus hyoideus, this nerve thus never reaching the external surface of the hyomandibular. The remainder of the facialis canal transmits the ramus mandibularis lateralis certainly accompanied by communis fibers, and possibly also by certain general cutaneous fibers. The nerve so constituted is joined, as it reaches the outer surface of the bone, by a communicating general cutaneous bundle which arises from the

trigeminus ganglion and issues through the trigeminus opening of the trigemino-facialis chamber, this being the second trigeminus bundle to join the facialis, the other bundle issuing through the facialis opening of the trigemino-facialis chamber, joining the nervus facialis internal to the hyomandibular, and going largely, if not entirely, to the ramus hyoideus. The ramus mandibularis, thus formed, after giving off certain branches, passes downward and inward through a large opening between the hind edge of the symplectic and the anterior edge of the web of bone that spans the angle between the two limbs of the preopercular, this opening being the regular foramen for the ramus mandibularis externus. Certain fibers other than lateralis ones form part of the nerve that passes through the foramen, but whether they are partly communis or wholly general cutaneous could not be determined in my material. It is, however, certain that, in this fish, no important bundle of communis fibers passes inward anterior to the symplectic, where the ramus mandibularis internus should normally pass, and, in my material, I could not there find an opening that I could certainly call a foramen and not an artifact. From the facialis canal, near its internal opening, a canal leads backward in the hyomandibular, as usual, opens on its external surface near its hind edge and immediately ventral to the opercular process, and transmits a nerve containing lateralis and general cutaneous fibers destined to innervate the dorsal two organs of the preopercular canal and tissues on the outer surface of the opercular.

The ramus hyoideus facialis thus never reaches the external surface of the hyomandibular, and it accordingly here has relations to that bone that might be taken to indicate that it was in process of cutting through the bone from its outer to its inner surface; but this is certainly not the case, the condition being in some way related to the development of that tall ridge on the external surface of the bone that gives support to the preopercular. This ridge lies, in certain fishes (Scorpaena, Trigla etc.), posterior to the external opening of the facialis canal through the hyomandibular, while in others (Scomber) it lies anterior to that opening. If, in one of these latter fishes, the ridge were to be pushed backward into the position, relative to the shank of the bone, that it has in Dactylopterus, it would probably pass over the ramus mandibularis, held in position by its lower foramen, but would push the ramus hyoideus downward and backward onto what would be morphologically a part of the posterior surface of the bone, though appearing as a part of its internal surface. An intermediate stage in such a process is shown in Gasterosteus, where, according to Swinnerton ('02, p. 544), „the hyomandibular nerve foramen occupies the same position as it did in the last stage, but externally at first sight it seems to have disappeared; in reality it has been carried to the ventral edge [of the hyomandibular] by overgrowth of bone".

The distal end of that slightly thickened portion of the hyomandibular that represents the shank of the bone is in synchondrosis with the usual interspace of cartilage, that cartilage being bounded anteriorly by the metapterygoid, antero-ventrally by the symplectic, and posteriorly by the web of bone that fills the angle between the two limbs of the preopercular. The interspace gives articulation, on its internal surface, to a relatively long and important interhyal. Immediately dorsal to this interspace of cartilage, the anterior edge of the hyomandibular is in contact with and firmly bound to the dorso-posterior corner of the metapterygoid, and between the two bones and the interspace of cartilage there is a relatively large foramen which transmits the arteria hyoidea.

The SYMPLECTIC is broad and flat, and lies in the line, prolonged, of the shank of the hyomandibular. Its ventral end overlaps the dorsal edge of the quadrate, and lies in a slight depression on the internal surface of that bone. The anterior edge of the bone is bounded externally by the

cartilage of the palato-quadrate apparatus, while internally it overlaps that cartilage and is in contact with the hind edge of the metapterygoid. Its hind edge is in part in contact with the anterior edge of the web of bone that spans the angle between the two limbs of the preopercular, and in part is separated from that web of bone by a relatively large opening. This opening is spanned by membrane, and the membrane is pierced by the arteria hyoidea and the ramus mandibularis externus facialis, the lateralis fibers of that nerve being accompanied by general cutaneous ones and possibly also by communis fibers, as just above explained. No mandibularis internus foramen, between the symplectic and quadrate, could be found.

The METAPTERYGOID is a subcircular bone slightly concave on its internal surface. It is bounded anteriorly by the entopterygoid, with which it is flexibly connected by tissue; ventrally by the quadrate, from which it is separated by a narrow band of cartilage; and posteriorly by the symplectic and the interspace of cartilage between the latter bone and the hyomandibular. A small posterior process at the dorsal end of its hind edge is in contact with and bound by tissue to the anterior edge of the ventral end of the hyomandibular, and this process is pierced by a foramen which transmits the external carotid from the outer to the inner surface of the apparatus, the artery there falling into the arteria hyoidea. In the ventral edge of the process there is a notch, which, with the adjoining cartilage, forms a foramen which transmits the arteria hyoidea from the outer to the inner surface of the apparatus. The process on the metapterygoid thus represents, as the hind edge of the bone in Cottus does, the two flanges on the hind edge of the bone of Scorpaena.

The QUADRATE has a large posterior process, the thick and broad postero-ventral surface of which rests against the dorsal surface of the ventral limb of the preopercular, the point of the process passing into a pocket in that bone. The symplectic groove is simply a broad and shallow depression on the internal surface of the dorsal edge of the bone, immediately anterior to this process. Dorsally the bone is bounded by cartilage which separates it from the metapterygoid, and the anterior edge of the bone forms, with that of the metapterygoid, a continuous line which is slightly convex and lies in a nearly transverse position. The narrow band of cartilage that lies between the two bones is prolonged a short distance beyond their anterior edges, there lies in a depression on the external surface of the entopterygoid, and is exposed on the outer surface of the apparatus between the ecto- and ento-pterygoids. The anterior edge of the quadrate overlaps internally the hind edge of the ectopterygoid, but is itself overlapped internally by a short process at the ventral corner of the latter bone, this latter process being in articular contact with the dorsal surface of the mesial end of the articular head of the quadrate. The quadrate and ectopterygoid thus articulate in a measure with each other, and as their adjoining edges are strongly but flexibly bound together by tissue, and as the anterior edge of the metapterygoid is similarly bound to the hind edge of the entopterygoid, a flexible joint is here formed in the hyomandibulo-palato-quadrate apparatus. The anterior prolongation of the band of cartilage that lies between the quadrate and metapterygoid crosses the joint uninterruptedly, but being itself flexible does not interfere with the movements of the parts. In the Cyprinidae, according to Sagemehl ('91, p. 582), the palato-quadrate apparatus is also jointed, but in those fishes the joint is between the palatine and the ecto- and ento-pterygoids and hence not similar to the joint in Dactylopterus.

The ECTOPTERYGOID is a stout elongated bone directed antero-dorsally. Its dorso-anterior end suturates with the palatine, the two bones enclosing between them a palatine remnant

of the palato-quadrate cartilage. The dorsal edge of the bone overlaps externally and suturates with the ventral edge of the entopterygoid, bounding, in its posterior portion, the short anterior prolongation of the palato-quadrate cartilage just above described. Its hind edge overlaps both externally and internally and articulates with the anterior edge of the quadrate, in the manner just above described. Near the ventro-posterior end of the free, ventral edge of the bone, there is a flat ridge-like process, the function of which was not evident in my preparations.

The ENTOPTERYGOID is a relatively large, thin, sub-oval bone, the anterior end of which overlaps internally the palatine, the ventral edge similarly overlapping the dorsal edge of the ectopterygoid. Its hind edge is flexibly bound to the anterior edge of the metapterygoid. In a slight depression on its outer surface, at its ventro-posterior corner, it lodges the short anterior prolongation of the palato-quadrate cartilage.

The PALATINE is a stout irregular bone, with a short body, a right-angled maxillary process, and a short ventral process the ventral edge of which is broadened and corrugated but bears no teeth. The hind end of the bone suturates with the ectopterygoid and entopterygoid, being overlapped externally by the former bone and internally by the latter. The three bones enclose between them a small palatine remnant of the palato-quadrate cartilage, this cartilage not being exposed on the outer surface of the apparatus. The maxillary process of the palatine is a stout process, the proximal portion of which is directed antero-dorso-laterally and the distal portion antero-ventro-mesially, the two parts lying nearly at a right angle to each other. The dorsal surface of the flat distal portion of the process lies against, and has a sliding articulation with the internal surface of the lachrymo-palatine process of the nasal bone, the ventral surface of the process giving articulation to, and being firmly bound by fibrous tissue to, the dorsal surface of the maxillary bone. Immediately posterior to the surface of contact with the nasal, the hind end of the flat dorsal surface of the maxillary process has a sliding articulation with the two little articular ridges on the internal surface of the dorsal edge of the lachrymal.

On the internal surface of the base of the maxillary process of the palatine, there is a V-shaped groove which has a wide dorsal end and from there tapers gradually downward to a point. This V-shaped groove articulates with the anterior edge of the lateral process of the vomer, and possibly also with adjacent portions of the corresponding edge of the pedicle of the ectethmoid, in the manner already described when describing those bones. Ventral to the groove there is, on the internal surface of the anterior end of the ventral process of the palatine, a concavity which gives insertion to the short vomero-palatine ligament and comes in contact with the lateral surface of the head of the vomer when the palato-quadrate apparatus swings inward. The dorsal edge of the body of the bone, and the dorsal edge of the entopterygoid immediately posterior to it, are both bound by strong tissue to the ventral surface of the pedicle of the ectopterygoid, touching that bone when the palato-quadrate apparatus swings inward.

The MANDIBLE contains dentary, articular and angular elements.

The dentary has the usual V-shaped hind end, the two limbs of the V being of about equal length. The ventral limb tapers gradually to a point, and its hind end lies in a deep groove along the internal surface of the articular. The dorsal limb of the bone is covered with small villiform teeth and ends in a flattened hind end which replaces functionally the dorsal end of a coronoid process, that process of the articular being wanting. On the external surface of the bone there is a deep groove

which doubtless lodges the anterior end of a gristly mandibular core, but this was not investigated in the preparation of my material. On the ventral surface of the dorsal limb of the bone is inserted the strong ligament that has its origin on the internal surfaces of the second and third infraorbital bones. The bone is traversed by the mandibular latero-sensory canal and lodges but two sense organs of the line.

The articular is a stout bone with a pointed anterior end which fits into the V between the two limbs of the dentary, lying on the dorsal surface of the ventral limb of that bone. On the ventral half of its internal surface is a deep V-shaped groove which receives the hind end of the ventral limb of the dentary. Near the hind end of this groove a canal traverses the bone from its ventral to its dorsal surface, but what it transmits was not determined. The bone is without coronoid process, and nearly its entire hind end is occupied by the articular facet for the quadrate. The bone is traversed by the mandibular latero-sensory canal and lodges one organ of that line.

The angular is a small bone that fits against the ventral surface of the articular, there forming a low, longitudinal and rounded ridge. At about the middle of its length there is a low transverse ridge, the posterior surface of which gives insertion to a ligament that has its origin on a rod-like bone that must represent the interopercular. From the hind end of this little bone a ligament extends posteriorly and has its origin on the external surface of the dorsal ossification of the ceratohyal, near its dorso-posterior end; the bone thus being intercalated in the mandibulo-hyoidean ligament, as a part of that ligament, but seeming nevertheless to represent the interopercular.

The OPERCULAR is, as Gill has said, a flexible subtriangular bone, the external surface of which is covered with scales.

The SUBOPERCULAR is said by Gill to be „almost membranous, mostly concealed", and to lie internal to the ventral end of the opercular. I find it as a relatively stout and curved bone, the dorsal end of which lies internal to the ventral end of the opercular, while the ventral end curves forward and lies against the internal surface of the preopercular; this latter end of the bone being directed toward but widely separated from the hind end of the interopercular. In Figure 71, which alone shows these bones, the line separating the subopercular and opercular has been omitted.

The INTEROPERCULAR is apparently represented, as Gill has stated and as just above described by me, by a rod-like bone intercalated in the mandibulo-hyoidean ligament.

4. LATERO-SENSORY CANALS.

The main infraorbital canal begins at the dorsal edge of the lachrymal, directly antero-ventral to the anterior end of the large nasal opening between the nasal and ectethmoid bones, there lying directly opposite and close to the anterior opening of the supraorbital canal. It runs at first ventro-laterally, then turns sharply backward at a right angle, and so continues in a nearly horizontal position until it has traversed the lachrymal and the anterior two-thirds of the second infraorbital bone. There it turns sharply upward and forward, at an acute angle, and curving backward and upward borders the hind edge of the orbit, traversing the second, third, and fourth infraorbital bones. At the anterior end of the horizontal part of its course, it sends a short branching tubule forward in the lachrymal, and at the hind end of this part of its course, it sends a long branching tubule directly backward nearly to the postero-ventral corner of the second infraorbital bone. Numerous other tubules arise from the canal in this part of its course, some of them being simple tubes while

others branch repeatedly, forming complicated dendritic systems. The tubules are scattered along the canal instead of being grouped together, and it is impossible from the tubules alone to determine the number of primary tubes. Furthermore, here, as in other parts of the latero-sensory system of this fish, the large dendritic systems arise from the canals in the bodies of the related bones, frequently near the middle point of the bone, and almost never in the sutural line between two bones; this being distinctly a characteristic of the canals in the chondrostean ganoids, here found in a teleostean fish. A full knowledge of the development of the system would accordingly be of considerable interest.

The main infraorbital canal, having left the dorsal one of the infraorbital bones, enters and traverses the postfrontal, at the dorsal end of which bone it turns sharply backward and enters the pterotic, anastomosing at the bend with what appears to be the terminal tube of the supraorbital canal. The main infraorbital then traverses in succession the pterotic and suprascapular, lying for a short distance, as it passes from one of these bones to the other, in a groove on the lateral edge of the lateral extrascapular. It then traverses a short tubular bone that lies along the lateral edge of the suprascapular and that apparently represents the latero-sensory component of the supraclavicular, as already set forth. As the canal traverses the pterotic it anastomoses with the dorsal end of the preopercular canal, and as it traverses the lateral edge of the lateral extrascapular, it gives off the supratemporal commissure.

In the main infraorbital canal there are three sense organs lodged in the lachrymal, two in the second infraorbital bone, three in the third infraorbital and one in the fourth infraorbital, all innervated by the ramus buccalis. In the postfrontal there is one organ innervated by the ramus oticus, and in the pterotic three organs, two innervated by the oticus and one by the supratemporalis lateralis vagi. In the section of canal that lies in the groove in the lateral extrascapular there is apparently no organ, but the organ usually found here may be represented in a part of the one organ found in this bone. This organ is unusually large, begins in the main canal, and from there extends postero-mesially in the supratemporal commissure, thus certainly belonging, in part at least, to that commissure. It is innervated by a single branch of the supratemporalis lateralis vagi. In the suprascapular there is one organ, innervated by the supratemporalis lateralis vagi.

The supratemporal canal begins at the lateral edge of the lateral extrascapular, opposite the sutural line between the pterotic and suprascapular, and running postero-mesially and then mesially traverses the lateral extrascapular and then the mesial extrascapular, anastomosing, at the mesial edge of the latter bone, with its fellow of the opposite side. Each of these two bones lodges a single sense organ innervated by a branch of the supratemporalis lateralis vagi.

The supraorbital canal begins at the lateral edge of the single median nasal bone, and from there runs upward and mesially, and then upward and backward in the nasal, curving around the anterior and then the mesial border of the large nasal opening of the skull. It then enters the anterior edge of the frontal and runs almost directly backward to the middle point of that bone. There it turns sharply laterally, and then curving laterally and backward reaches the postero-lateral edge of the frontal, where it anastomoses, by what is apparently its terminal tube, with the main infraorbital canal. In the full length of the canal there are, as in all the other fishes of the group, six sense organs, one in the nasal and five in the frontal, all innervated by the ophthalmicus lateralis; but in Dactylopterus the relations of the organs in the frontal to the frontal commissure are not as in those other fishes. Here, three organs lie anterior to the commissure and two posterior to it, the commissure

accordingly being formed by what is, in its relations to the organs, the fifth instead of the fourth tube of the line. Furthermore, there is no primary tube between the first and second frontal organs, and it is apparently the terminal tube of the line, instead of the penultimate tube, that anastomoses with the main infraorbital canal.

The preoperculo-mandibular canal anastomoses by its dorsal end with the main infraorbital as that canal traverses the pterotic. The canal traverses, as usual, the preopercular, articular and dentary, the former bone lodging six sense organs, the articular lodging one organ, and the dentary two organs; all innervated by the mandibularis externus facialis.

III. THE MYODOME.

Having found a myodome in Dactylopterus, in which fish it is said by Gill ('88) and other authors to be wholly wanting, I have been led to look up, as fully as the literature and material at my disposal would permit, all other teleosts in which this canal is also said to be absent. Before discussing these other teleosts it is, however, necessary to quite fully describe the related conditions in Lepidosteus; for a proper understanding of the conditions in that fish, already briefly described by Sagemehl, is most important in this connection.

Of Lepidosteus Sagemehl says ('84b, p. 86); „Bei Lepidosteus wird durch besondere Fortsätze der Petrosa ein nach vorn gegen die Schädelhöhle geöffneter Halbkanal gebildet, der dicht hinter der Hypophyse von einer Seite zur anderen verläuft und nach vorn, also gegen die Hypophyse hin, durch eine Membran vollständig abgeschlossen und zu einem allseitig gedeckten Querkanal verwandelt wird, welcher von lockerem Fettgewebe erfüllt ist. Lateral reicht dieser an der Basis cranii dicht hinter der Hypophyse verlaufende Kanal bis an den hinteren, unteren Winkel der Orbita, nach welcher hin er vollständig verschlossen erscheint. Abgesehen von dem letzteren Umstande besitzt dieser Raum genau dieselben Verhältnisse, wie der von Gegenbaur beschriebene Canalis transversus der Selachier; der Verschluß gegen die Orbitae ist wohl ein sekundärer. Auf der anderen Seite kann es eben so wenig einem Zweifel unterliegen, daß dieses der Augenmuskelkanal von Amia ist, wenn man die hier gegebene Beschreibung mit der Fig. 7 meiner Arbeit über Amia vergleicht, wo der unter dem horizontalen Fortsatz des Petrosum und vor demselben gelegene durch eine Fascie (die nicht abgebildet ist) zugedeckte Raum von dem Rectus externus eingenommen wird. Die von Gegenbaur vertretene Hypothese kann somit durch weitere Tatsachen gestützt werden."

In the adult Lepidosteus the brain case, in the region of the pituitary body, is somewhat more than twice as wide as it is tall. In a 19 mm embryo these two dimensions, in this same region, are nearly equal. There is thus, in this region, a flattening of the brain case as the fish develops, and this flattening process seems to particularly affect the ventral portion of the brain case. Because of it, the ascending processes of the parasphenoid of the adult are flat plates, projecting almost directly laterally from the body of the bone. Their lines of origin from the body of the bone incline backward and slightly upward, the two processes thus lying practically in the same plane, and that plane being a transverse one that inclines but slightly upward and backward to the axis of the parasphenoid. Each process is, in extent and position, the equivalent of the ascending process of Parker's ('82b) figures of young Lepidostei fused with the so-called alisphenoid bone of those same figures, Parker showing these latter bones as separate and independent ones in 2 and 4 inch larvae and describing them as such in the adult.

In larvae 55 and 80 mm in length, I find, occupying the place of the alisphenoid bone of Parker's descriptions, a V-shaped process of the parasphenoid which embraces the mesial edge of an anterior plate-like process of the proötic cartilage. This process of the proötic cartilage occupies the place of, and certainly is the basipterygoid process of Parker's descriptions, but it has a short free mesial edge not shown by Parker. The anterior edge of the V-shaped process of the parasphenoid is closed by a rounded union of the plates that form its two limbs, and the limbs are here both short, extending laterally only about one third the width of the cartilage. This rounded anterior edge of the process, and the corresponding edge of the cartilage beyond it, together, give articulation to the metapterygoid. The point of the V of the V-shaped process is directed mesially toward the lateral edge of the parasphenoid, but it does not, in its anterior portion, quite reach that edge. Posteriorly it meets and fuses with the edge of the parasphenoid, thus becoming a part of the ascending process of that bone. The dorsal (internal) limb of the V there vanishes, while the ventral (external) limb becomes prolonged into that tall plate of the ascending process of the parasphenoid that lies against the external surface of the proötic cartilage. In 19 mm and 25 mm specimens, which I have also examined, the internal limb of the V-shaped process has not yet developed, the external limb alone being found. The V-shaped process of older specimens is thus, in these young larvae, simply a plate-like part of the ascending process of the parasphenoid which, projecting forward, forms the lateral boundary of a narrow space, or notch, between itself and the lateral edge of the body of the parasphenoid. Through this notch the efferent pseudobranchial artery runs upward, and then turns mesially between the body of the parasphenoid and the overlying cartilaginous basis cranii, to join and completely fuse with the internal carotid. Immediately posterior to the notch, the ventro-mesial edge of the base of the basipterygoid process of the proötic cartilage fuses with the ventral surface of the lateral edge of a short band-like portion of the cartilage of the region, this latter cartilage bounding the space in which the hypophysis lies. Posteriorly this band is continuous with the parachordal cartilage, while anteriorly the lateral end of its nearly straight anterior edge is continuous with the thickened ventral edge of the cartilage of the alisphenoid region; that thickened edge of the alisphenoid cartilage being continuous, anteriorly, with the hind end of a median portion of the trabecular cartilage. Whether the short band of cartilage is of trabecular origin, or not, I can not positively tell, but it would seem as if the trabecular cartilage could not extend posteriorly, on either side, beyond the hind end of the thickened ventral edge of the alisphenoid cartilage. This being the case, the short band of cartilage would represent the anterior end of the parachordal cartilage, and as such I consider it; the hypophysis then lying between the anterior ends of the parachordal cartilages. Parker shows this part of the chondrocranium of Lepidosteus somewhat different from what I find it, and he considers the cartilage of this region as of trabecular origin; but he also considers the basipterygoid process as of trabecular origin, and that cartilage, being a process of the proötic cartilage, must certainly be of post-trabecular origin.

The basipterygoid process of Lepidosteus, it may here be stated, has so closely the position and the relations to the nerves and blood vessels of the region that the basipterygoid process of Lacerta has (Gaupp, '00, p. 537), that it must be the homologue of that process. In Amia, it is apparently represented in the little cartilaginous process that is perforated by the efferent pseudobranchial artery (Allis, '97a), and that rises from the lateral edge of what is apparently the hind end of the fused trabeculae. In most teleosts the process seems wholly wanting.

Parker's alisphenoid bone is thus, as I find it, even in 55 mm specimens, simply a part of the ascending process of the parasphenoid, and I am unable to explain how Parker could have found it, separate and independent, not only in a 2 inch (50 mm) but also in a 4 inch (100 mm) specimen. Parker furthermore states that his alisphenoid is an endosteal bone. In my 55 mm and 80 mm embryos the corresponding basipterygoid process of the parasphenoid is, in its anterior portion, surrounded by dense tissue the character and origin of which I am unable to determine, not being sufficiently versed in the subject; but it would seem to result, in part, from the breaking down of the superficial layers of the cartilage against which the bone lies. In the 19 mm and 25 mm specimens this dense tissue is already being developed, but at these ages the tissue lies almost entirely between the bone and the cartilage, and it may accordingly be wholly of perichondrial origin. Whatever its origin, this part of the parasphenoid certainly has relations to the underlying cartilage somewhat different from those of the other portions of the bone, and it would seem to be a typical case of a dermal bone in process of acquiring primary relations to an underlying cartilage. It is, however, to be noted that perichondrial bone has nowhere else appeared, in the earliest of the stages examined, and that when it does appear it is not imbedded in dense formative tissues, as the bone here in question is. In the adult this part of the ascending process of the parasphenoid certainly has much the appearance of perichondrial bone; but it runs insensibly into the posterior portion of the process, where both plates of the V-shaped portion of the bone are certainly of ectosteal origin, for they both extend beyond the dorso-lateral edge of the cartilage they enclose, and there overlap, superficially, portions of the inner and outer surfaces of the ventro-mesial edge of the proötic bone. But, whatever its origin, this part of the parasphenoid is certainly not the alisphenoid, for that bone is found elsewhere, in its proper place, as a wholly independent ossification.

In the adult, on the anterior edge of the basipterygoid portion of the ascending process of the parasphenoid, there is a tit-like process which projects toward and sometimes even abuts firmly against the lateral surface of the body of the parasphenoid slightly anterior to the base of its ascending process. This little process lies in a horizontal position, at right angles to the axis of the parasphenoid, and between it and the anterior edge of the basal portion of the ascending process there is a more or less completely closed opening which transmits the efferent pseudobranchial artery. The anterior edge of the tit-like process is straight and forms part of the articular surface for the metapterygoid, the remainder of that articular surface being formed by the straight anterior edge of the basipterygoid process and a corresponding edge of that part of the proötic cartilage that lies dorso-lateral to the process. This little tit-like process is thus a mesial growth of the anterior end of the V-shaped part of the bone of embryos, and it is to be remarked that, although it may abut firmly against the body of the parasphenoid, I have never found it fused with that bone. It is not shown in any of Parker's figures, but the general arrangement of the parts can be readily understood by reference to those figures.

Between the proötic bone and the hind edge of the external plate of the ascending process of the parasphenoid, there is an opening which leads into a short canal between the parasphenoid and the overlying cartilage of the basis cranii, the opening thus having exactly the position of the internal carotid foramen of Amia and teleosts, and unquestionably being the homologue of that foramen. In Lepidosteus, however, this foramen transmits the common carotid, which artery, immediately within the foramen, separates into its external and internal branches. The external carotid, turning upward, traverses a foramen that perforates the ventro-mesial edge of the proötic, but lies partly in that bone and partly in the cartilage that bounds it. The artery then runs upward

and backward in a deep groove that lies on the orbital surface of the proötic and that leads into a large trigemino-facialis chamber. This groove, in Lepidosteus, transmits the ramus palatinus facialis as well as the external carotid artery, the nerve traversing the foramen in the proötic with the artery, and entering the carotid canal. This foramen in the proötic of Lepidosteus is accordingly the homologue of the palatinus and external carotid foramina of Amia, coalesced into a single opening. It has closely the position of the palatinus foramen of Amia, and neither it nor the carotid foramen are shown by Parker in any of his figures.

In sections of embryos, a delicate pharyngeal branch of the glossopharyngeus is found accompanying the common carotid artery, and although it could not be traced as far as the carotid foramen, it doubtless traverses that foramen, with the artery, as in Amia.

The internal carotid artery, having separated from the external carotid immediately beneath the palatinus foramen, runs forward in a canal between the cartilage of the basis cranii and the underlying parasphenoid, lying in a slight groove on the dorsal surface of the latter bone. It is accompanied, in this canal, by the ramus palatinus facialis and probably also by the delicate branch of the glossopharyngeus just above described. Having arrived near the anterior edge of the ascending process of the parasphenoid, and there lying anterior to the pituitary fossa, the internal carotid receives the efferent pseudobranchial artery. It then, in all my embryos, immediately separates into two parts. In the smaller embryos, these two parts both turn upward and traverse the intertrabecular space, while in the older embryos, they perforate the overlying cartilage and so enter the cranial cavity, one part traversing a large foramen and the other traversing a small and imperfectly enclosed branch canal which leads from that foramen. The larger one of these two branches gives off several intracranial branches and then leaves the cranial cavity with the nervus opticus. The smaller branch also issues with the opticus, but it gives off no perceptible branches during its intracranial course, and it may perhaps be reminiscent of the otherwise wholly wanting anterior continuation of the efferent pseudobranchial artery. Shortly before the anastomosis with the efferent pseudobranchial artery, the internal carotid gives off a small branch which runs forward, accompanying the palatinus facialis, in an anterior prolongation of the canal between the parasphenoid and the overlying cartilage of the base of the skull. This latter artery and the two carotids are all three briefly mentioned by Wright ('85) in his description of the arterial circulation in embryos of Lepidosteus, but their foramina and their courses relative to the cranium are not well or sufficiently given by him.

In the adult, the trabeculae of opposite sides have fused with each other in the middle line, and the internal carotids traverse foramina in the basis cranii, these foramina corresponding to the internal carotid canals of my descriptions of Amia ('97). Slightly anterior to these canals there is a shallow transverse groove across the dorsal surface of the fused trabeculae, this groove corresponding exactly, in position, to the canalis transversus of my descriptions of Amia, and being quite undoubtedly the homologue of that canal. The groove is, however, not the homologue of the canalis transversus of selachians, as I have pointed out in a later work ('01), and the selection of the name, in my descriptions of Amia, was unfortunate. The groove, in Lepidosteus, forms the anterior boundary of a slightly raised portion of the cartilage of the basis cranii, which extends backward to the anterior edge of the pituitary fossa and is the homologue of the much more pronounced transverse prepituitary bolster of Amia.

The pseudobranchial artery, in Amia, does not itself fuse with the internal carotid, a small communicating branch, only, which perforates a lateral projection of the basis cranii, uniting the

two arteries. In Lepidosteus, it is the main efferent pseudobranchial artery, itself, that here unites with the internal carotid, traversing, to reach that artery, the imperfectly closed foramen in the anterior edge of the ascending process of the parasphenoid. This difference in this artery, in these two fishes, is doubtless due to the absence of a choroid gland in Lepidosteus; that orbital continuation of the artery that supplies that gland in Amia naturally being suppressed with the gland, in Lepidosteus, and the communicating branch of Amia becoming, in Lepidosteus, the direct anterior continuation of the main artery.

The palatinus facialis and external carotid of Lepidosteus run upward and backward, as already stated, in a groove that leads into a trigemino-facialis chamber in the proötic. This chamber has a very large trigeminus, and a smaller facialis opening, and its bony mesial wall is a direct posterior continuation of the bony wall that encloses the anterior part of the cranial cavity; Lepidosteus, in this, resembling Scomber and the mail-cheeked fishes, and differing markedly from Amia. The mesial wall of the chamber is perforated by a single large foramen for the roots of the trigemino-facialis nerves, two small processes representing the beginnings of a separation of the foramen into two or more parts. Slightly antero-ventral to this foramen the anterior edge of the proötic is perforated by another foramen, the anterior border of which is formed by a small flat bar of cartilage which, rising from the trabecular cartilage and extending upward to the ventral edge of the alisphenoid, separates the foramen from the ventral portion of the optic fenestra. This foramen transmits the pituitary vein, which vein arises beneath the hypophysis, in direct communication with its fellow of the opposite side, and from there runs dorso-antero-laterally to traverse its foramen and fall into the (internal ?) jugular slightly posterior to the point where that vein is joined by the orbito-nasal vein. The pituitary vein receives a small branch, on either side, from the cross-canal of Sagemehl's descriptions, these branches being traced in sections and not in the adult. The vein, in the adult, lies, in its intracranial course, beneath a mass of fatty tissue which covers the floor of the cranial cavity, and this fatty tissue in the cranial cavity of the skull of fishes is said by Sagemehl ('84a) to lie between inner and outer limiting membranes which are parts of the dura mater. Some part of this tissue, in Lepidosteus, is accordingly the homologue of the tough glistening membrane that, in Amia, forms not only the roof of the anterior portion of the myodome, but also the mesial wall of the trigemino-facialis chamber of that fish. The foramen that transmits the pituitary vein, in Lepidosteus, is thus quite certainly the equivalent of some part of the ventral portion of the orbital opening of the myodome of Amia.

Immediately dorsal to the foramen for the pituitary vein, between the adjoining edges of the proötic and alisphenoid, there is another foramen, which transmits the nervus oculomotorius and probably the radix profundi also, for although this latter nerve, in my 80 mm specimen, pierces the cartilaginous cranial wall close to but wholly separate from the oculomotorius, I do not find a separate foramen in the one adult skull that I have examined in this connection. Van Wijhe ('82) says that he found the profundus issuing by a separate and independent foramen. Somewhat dorsal to these two foramina, in the sections of my 80 mm specimen, the trochlearis pierces the cranial wall, and, slightly posterior to that nerve, the wall is perforated by a branch of the orbito-nasal vein. These two latter foramina are, one or both, represented, in my adult specimen, in a short canal that traverses the alisphenoid slightly dorsal to the oculomotorius foramen.

Stannius ('49, p. 19) says that, according to Müller, the oculomotorius, trochlearis and trigeminus of Lepidosteus all issue through a single large foramen in the „Keilbeinflügel": a statement that is certainly not wholly correct.

A short leg of the alisphenoid forms, in the adult, the anterior boundary of the oculomotorius foramen, the ventral end of the leg being continuous with the small flat bar of cartilage that lies between the ventral portion of the optic fenestra and the foramen for the pituitary vein; and as this bar of cartilage rises from the lateral edge of the basisphenoid region of the trabecular cartilage, the associated leg of the alisphenoid must be the basisphenoid leg of that bone. Of the parasphenoid leg of the alisphenoid I can find no trace, the alisphenoid of Lepidosteus thus being strictly of the usual teleostean type.

The recti muscles of the eye all have their origins from the skull immediately ventral and posterior to the optic fenestra, and hence in the immediate neighbourhood of the foramen for the pituitary vein. The rectus externus, in the 80 mm specimen, separates into two portions as it approaches the skull, and the tendon of one of these portions traverses the foramen with the vein, and, following it, has its origin beneath it; but whether its point of origin is on the cartilage of the basis cranii, on the parasphenoid, or in fibrous tissue of the region, I could not determine.

Although wholly unrelated to the present subject, it may here be stated that the rectus internus arises, in Lepidosteus, by a long and slender tendon which is closely applied to the antero-mesial surface of the rectus inferior, these two muscles thus arising as a single muscle and being, practically, not yet fully differentiated parts of a single muscle; this being in accord with my supposition (97a) that these two muscles of teleosts and bony ganoids arise by the splitting of the single rectus inferior of elasmobranchs. These two muscles, and the rectus superior and obliquus inferior, are innervated by the oculomotorius in the manner and order that they are in Amia, this confirming my interpretation ('97a, p. 520) of Van Wijhe's description of this fish. The abducens leaves the cranial cavity through the trigemino-facialis foramen, piercing the membrane that closes that foramen antero-ventral to and independent of the trigemino-facialis roots. It then runs antero-laterally, ventral to the jugular vein, between it and the external carotid, lying internal and antero-internal to the ventral edge of the trigemino-facialis ganglion, and reaches the rectus externus. It does not pass over the truncus trigeminus, as stated by Schneider ('81), but, as the rectus externus passes over that truncus, the abducens naturally also would, if it were sufficiently prolonged. The radix profundi, after its exit from the skull, enters an extra-cranial profundus ganglion which lies close against the side wall of the skull immediately dorso external to and in contact with the oculomotorius, and not below that nerve, as shown by Schneider. Two ventral or ventro-anterior prolongations of the ganglion terminate in small ganglionic swellings, which lie in contact with the inferior branch of the oculomotorius and are the ciliary ganglia. From the anterior end of the profundus ganglion a stout portio ophthalmici profundi arises. The trigemino-facialis ganglion lies, as in Amia, wholly outside the cavum cranii, a few scattered cells only being found in the roots of the nerves.

The cross-canal of Sagemehl's descriptions can now be considered. The enclosing walls of this canal form, in the fresh skull of the adult fish, a prominent transverse bolster on the floor of the cranial cavity, and this bolster must quite unquestionably have arisen by the depression of the anterior edge of the proötic bridge of a fish like Amia (Allis, '97a, Fig. 11) or Polypterus (Pollard, '92, Fig. 12) until it met and then fused with the floor of the cranial cavity on either side of the saccus vasculosus. The cross-canal of Lepidosteus is thus a strictly intramural space that lies beneath a proötic bridge of the primary type found in Amia, and that is related either primarily or secondarily to the saccus vasculosus. This space represents the posterior half only of the myodome of Amia, and it might have been developed either from the conditions found in that fish, which

has a myodome, or from those found in Polypterus which has no myodome. In Lepidosteus the mesial processes of the proötics, which unite to form the proötic bridge, are said by Sagemehl to be connected, across the median line, by membrane, instead of by cartilage. To me this connecting tissue looks much more like cartilage or fibro-cartilage than like membrane, but this is unimportant, for even in Amia membrane is here first formed and later chondrifies. Sagemehl further says that this membrane entirely closes the canal toward the cranial cavity. This is an error, for I find the anterior wall of the canal always perforated by a median oval opening through which the apparently short saccus vasculosus projects. The cross-canal is filled, as Sagemehl states, with a mass of fatty tissue and this tissue is richly supplied with blood.

Immediately anterior to the cross-canal there is, in the floor of the cranial cavity, the pit-like and slightly oval pituitary fossa. The lateral and anterior walls of this fossa are of cartilage. The floor of the fossa is perforated by a nearly circular opening, the opening being closed ventrally by the parasphenoid. Posterior to this circular opening, and extending to or slightly beyond the anterior wall of the cross-canal, the floor of the pit is, in my medium-sized adults, formed of tough membrane only. Posterior to this membrane the floor of the cross-canal is of cartilage, and inclines gradually and slightly upward to the base of the ridge of cartilage that forms the posterior boundary of the cross-canal. The circular opening in the cranial floor is accordingly the hypophysial fenestra, the greatly reduced pituitary space, or pituitary fenestra of Parker's descriptions of embryos of Lepidosteus, and this fenestra of the adult Lepidosteus is the strict, but reduced homologue of the hypophysial fenestra of Amia. The fenestra of Lepidosteus is said by Parker to lie between the „roots" of the trabeculae; but, as already stated, the laterally bounding cartilages seem to me to be the anterior ends of the parachordal cartilages. Parker's opinion was doubtless based; Ist., on the position of the hypophysis, in early embryos, between the hind ends of the trabeculae; and, 2nd. on the position of the posterior clinoid bridge of his descriptions, which bridge is said by him (l. c. p. 481) to run „straight across, joining the roots of the trabeculae together". But, this posterior clinoid bridge simply represents an early stage in the development of the enclosing walls of Sagemehl's cross-canal, and hence joins regions of parachordal and not of trabecular origin. Furthermore, the position of the hypophysis in early embryos need not necessarily be the same as that in the adult. For, the intertrabecular and interparachordal fenestrae of early embryos being continuous, as shown by Parker, the well-known unequal longitudinal growth of the cartilage of the basis cranii and the overlying brain might easily pull the pituitary body backward, out of the hind end of the intertrabecular space into the interparachordal region. And this, in my opinion, has certainly taken place in Lepidosteus.

Sagemehl says that the lateral ends of the cross-canal closely approach the postero-ventral corner of the orbit. This is an error, for the cross-canal is everywhere widely separated from the orbit. He further says that the cross-canal exactly resembles the canalis transversus of selachians, excepting that it is closed toward the orbit. This also is not wholly correct, for as the canalis transversus of selachians is traversed (Allis, '01) by a venous sinus and not simply by a lymph sinus, as Sagemehl supposed, it must be represented, in part at least, in Lepidosteus, by the canal that transmits the pituitary vein. There are here, in fact, two spaces that would seem to be of separate and independent origin; one a median space that is either primarily or secondarily related to the saccus vasculosus, and the other a canal that leads from the orbit, on either side, and is traversed by the pituitary vein. The saccular space is roofed by the mesial processes of the proötics, and from it, or immediately in front

of it, the canal for the pituitary vein leads on either side into the orbit, lying ventral and then lateral, or antero-lateral to the hypophysis.

The conditions in Lepidosteus thus all indicate that the myodome of Amia would arise if certain of the recti muscles of the former should force an entrance into the cranial cavity, and then into the saccular space, traversing, in this process, the foramen and then the canal for the pituitary vein. The recti muscles, as already stated, already have their origins in the immediate vicinity of the foramen for the vein, and one head of the rectus externus has, in my 80 mm specimen, already acquired a very considerably intracranial extension. If this head of this muscle were to continue its progress, at the same time increasing largely in size, it would, following the vein, make its way backward between the cartilaginous floor of the cranial cavity and the overlying membrane, would force that membrane and the overlying brain upward in the cranial cavity, and might finally reach and break down the anterior wall of the cross-canal; the myodome of Amia thus being produced. And this is, in principle, the manner in which Sagemehl suggests that the teleostean myodome did arise, although in the details of his explanation he is wrong. The conditions in Lepidosteus might however represent a stage in the abortion of the conditions that preceded and led to the establishment of a myodome, those pre-existing conditions being represented in Polypterus; and this seems to me the proper interpretation of the facts, as will be later discussed.

But, whatever the origin of the myodome, there are in Lepidosteus, as there are in Amia and Scorpaena, two floors in the pituitary region of the cranial cavity, the dorsal one of these two floors being membranous to a different extent in each of these three fishes. The lateral walls of this part of the skull are also double in each of these three fishes, one or the other of the two walls being also membranous to a different extent in each of the fishes. In the space between the two floors lies the myodome, either actual or potential, while in the space between the two lateral walls lies the trigemino-facialis chamber. In Dactylopterus the conditions are modified and obscured by the fact that the dorsal floor arises from or near the anterior edge of the ventral floor and is inclined at a marked angle to it.

According to Starks ('05), the ventral floor of the myodome of fishes „is the true cranial base", the dorsal floor being simply a septum of secondary development; and the conditions that I have described in Amia would seem to favor this interpretation, the dorsal wall of the myodome chondrifying, in that fish, much later than the ventral wall. But this condition is not invariable in fishes, as Handrick's ('01) descriptions of Argyropelecus show. In that fish the myodome is said to begin beneath the membranous pituitary fossa, and from there to extend backward immediately beneath the cartilaginous floor of the cranium until it reaches and ends against the „anterior outer wall" of the bulla that encloses the sacculi and lagenae. The side walls and floor of this myodome are not particularly described, but they are evidently formed by portions of the hard, modified, connective-tissue membrane that is said to largely cover the roof and side walls of the cartilaginous cranium, and the trigemino-facialis chamber of either side would seem to be in direct communication with the myodome, as it is in Amia. The trigeminus ganglion is said to be an extracranial one, and to lie in the upper corner of the myodome. The ciliary ganglion is also said to lie in the myodome, while the sympathetic ganglion is said to lie on the outside of the side wall of the myodome, and the communis and lateralis ganglia of the V—VII complex, which evidently form the large so-called facialis ganglion, to lie entirely within the cartilaginous cranium. The cartilaginous wall of the cranium is said to be perforated, on either side, by three separate foramina, one of which transmits the nervus oculo-

motorius, a second the root of the trigeminus accompanied by a single trunk from which arise the ophthalmicus and buccalis lateralis, and a third the truncus facialis accompanied by the palatinus facialis and nervus abducens. The root of the trigeminus evidently includes the radix profundi, but whether the ganglion of that nerve is intracranial or extracranial is not evident. It is however plainly evident that the cartilaginous floor of the cranium, immediately posterior to the pituitary fossa, is a proötic bridge, and that the side wall of the cranium on either side of the pituitary region represents the inner wall of the trigemino-facialis chamber, the outer wall of that chamber, and also the ventral wall of the myodome, being wholly of membrane.

It is thus evident that no positive conclusion can be formed as to which one of the two floors of this part of the skull of fishes is the primary, and which the secondary one, until it is first known what parts of the membranes here concerned belong to the primordial membranous capsule of the brain and what parts, if any, are developed independently, internal to that capsule, as protective coverings to the brain. The myodome, as it actually exists, is however certainly a space in the dura mater, as that membrane is defined by Sagemehl in his descriptions of Amia, and as both its inner and its outer walls may in large part chondrify or ossify as parts of the cranial wall, the myodome is an intramural and not an intracranial space. This I have already stated in an earlier work ('97b, p. 10), there speaking of the myodome as an intracranial space, but qualifying this by saying that it is „a space that certainly lies morphologically in, and not internal to, the membranous bounding walls of the primordial skull".

In the labyrinth region also, both the ventral and the lateral walls of the skull of fishes are partly double, the sacculi of the membranous ear lying between the two ventral walls and the semicircular canals between the lateral walls. The inner one of these two walls is largely membranous in teleosts and the bony ganoids, but it may partly ossify as the mesial processes of the exoccipitals. In elasmobranchs the wall may be largely of cartilage.

In most prepared skulls these two walls of the skull of fishes are not apparent, for their membranous portions can only be preserved in careful preparations, and are almost always entirely removed. In serial sections of embryos, also, particularly of early embryos, the membranous portions of these walls are apt not to be recognized as such. Yet the fact that they both exist must always be carefully borne in mind, for it, alone, permits of a proper comparison of this region, not only of fishes with one another but of fishes with higher vertebrates.

In the chondrocranium of embryos of Lacerta agilis the hypophysis lies, according to Gaupp ('00, p. 470), in a hypophysial fenestra bounded laterally by the diverging hind ends of the trabeculae, and posteriorly by a transverse bar of parachordal cartilage, called by Gaupp the crista sellaris. This crista sellaris unites the anterior ends of the parachordal plates, and separates the interparachordal fontanelle from the intertrabecular fontanelle, or hypophysial fenestra; thus having approximately, if not exactly, the position of the posterior clinoid bridge of Parker's descriptions of Lepidosteus. The carotis cerebralis, on either side, traverses, in early stages, the postero-lateral corner of the hypophysial fenestra, but in later stages it becomes entirely enclosed in cartilage, in an independent carotid foramen. Slightly anterior to the hypophysial fenestra lies the subiculum infundibuli, a V-shaped cartilaginous plate that rises from the hind edge of the interorbital septum. Anteriorly, this plate of cartilage forms part of the hind border of the optic fenestra, while posteriorly it gives support to the anterior border of the lobus infundibularis. The V-shaped plate of cartilage thus has strikingly the position of the basisphenoid cartilage of Scorpaena, and this latter cartilage has been shown

to be the homologue of the transverse prepituitary bolster of Amia. The lateral edge of the plate, in Lacerta, is connected, on either side, by the pila metoptica, with the taenia parietalis media, this latter structure being a horizontal bar of cartilage that forms part of the side wall of the cranial cavity. The pila metoptica forms part of the anterior boundary of the fenestra metoptica, which transmits the oculomotorius and trochlearis nerves; those nerves thus undoubtedly running forward lateral to the pila metoptica, into the orbit. The cartilaginous pila metoptica of Lacerta thus corresponds, in its relations to these two nerves, to the basisphenoid leg of the alisphenoid bone of Lepidosteus, and to the fibrous tissue that, in Amia, represent the same leg and forms the mesial boundary of the tall orbital opening of the myodome. In Amia, the relations of the two nerves to the basisphenoid leg of the alisphenoid are not positively indicated, that leg being represented by an undefined portion of a continuous membrane. In teleosts, the oculomotorius issues, in all the fishes I have examined, posterior to the sutural connection of the alisphenoid with the basisphenoid, and hence lies posterior to the basisphenoid leg of the alisphenoid. The trochlearis has however in teleosts the same indefinite relations to the basisphenoid leg of the alisphenoid that it has in Amia, for it issues along the ventral or ventro-anterior edge of the alisphenoid, but anterior to the sutural connection of that bone with the basisphenoid. It must accordingly either lie anterior to the basisphenoid leg of the bone, or perforate an unossified portion of that leg; probably the latter.

In Lacerta the hypophysis lies posterior to the subiculum infundibuli, between it and the crista sellaris. Lateral to the crista sellaris, the nervus abducens pierces the basal parachordal plate, near its anterior edge, and, running forward in the plate, opens on its very edge; the foramen not being shown in ventral views. From there the nerve must run forward dorsal to the trabeculae, as it does in the Frog (Gaupp, '93a) and Necturus (Platt, '97), and in this part of its course it must lie between the trabeculae and an overlying membrane of some kind, doubtless a somewhat differentiated layer of the dura mater. This membrane would certainly underlie the hypophysis and so represent a membranous floor of this part of the cranial cavity, but to what extent it is developed or differentiated, I can not determine from the literature at my disposal. Assume it to be well developed. It would extend between the subiculum infundibuli and the crista sellaris, forming a membranous fossa around the hypophysis, and leaving a space between itself and the underlying cartilage of the skull. This space must be traversed by the vein that is said by Gaupp ('93b, p. 571) to run forward from the hypophysis into the orbit, and which is the evident homologue of the pituitary vein of my descriptions of Amia, Lepidosteus and Scorpaena. The space must, furthermore, be traversed by the carotid artery, which artery having either traversed the hypophysial fenestra or a closely adjoining and independent foramen, is said by Gaupp (l. c. p. 571) to run forward close to the brain; thus doubtless passing dorsal to the subiculum infundibuli. These conditions in Lacerta are thus all too similar to those in the fishes referred to not to warrant the following conclusions: (1) that the cartilaginous floor of the cranial cavity of Lacerta is probably the homologue of the ventral floor of the myodome of fishes; (2) that there is, in the pituitary region of this skull, and dorsal to the cartilaginous floor, a space of uncertain dimensions which corresponds to a part, if not to the whole, of the myodome of fishes; (3) that the hypophysial fenestra of Lacerta is consequently the strict homologue of the hypophysial fenestra of Lepidosteus; and (4) that the subiculum infundibuli is the homologue of the basisphenoid cartilage of Scorpaena, and hence of the transverse prepituitary bolster of Amia.

With the human skull I have already attempted, in an earlier work ('97b), to compare the condition found in Amia, and certain conclusions there arrived at can be repeated here with additional facts in their support.

In Man (Quain '92 96), the Gasserian ganglion lies in the cavum Meckelii, that cavum being said to be a recess in the dura mater which occupies a depression on the upper surface of the petrous portion of the temporal bone. But this so-called recess must be a space in the dura mater and not a simple recess on its cerebral surface; for elsewhere in the same work the Gasserian ganglion is said to lie between the inner and outer layers of the dura, the inner one of these two layers being the primitive, single-layered dura, and the outer one being the endocranium, or internal periosteal membrane of the skull. The fusion of these two separate membranes of embryos is said to form the double-layered dura of the adult, the Gasserian ganglion being, in this process, enclosed between the two layers. The internal part of the cavum Meckelii is said to come into close relations with the posterior extremity of the cavernous sinus, that sinus also being a space between the two layers of the dura of the adult, and the sinuses of opposite sides being in communication by means of the intercavernous sinuses. Between the cavernous sinuses of opposite sides, in a median depression on the dorsal surface of the dura, lies the pituitary body. The cavernous sinuses each receive the ophthalmic vein anteriorly, these veins communicating with each other across the middle line by means of the intercavernous sinuses, and discharging their blood posteriorly into the petrosal sinuses. The intercommunicating veins are accordingly the homologues of the pituitary veins of my descriptions of fishes, and the cavernous sinuses, intercavernous sinuses, and Cava Meckelii are together the apparently strict homologues of the myodome of Amia; that myodome consisting, as I have already explained, of a ventral portion which is the homologue of the myodome of teleosts, and an upper lateral chamber, on either side, which is the homologue of the trigemino-facialis chamber of teleosts.

The outer wall of each cavernous sinus is traversed by the oculomotorius, trochlearis and abducens nerves, by the ophthalmic and superior maxillary branches of the trigeminus, and by the internal carotid artery. Having traversed the wall of the sinus, the oculomotorius, trochlearis, abducens and ophthalmicus trigemini all issue into the hind part of the orbit through the sphenoidal fissure, that fissure lying between the great and small wings of the sphenoid bones, the former of which is said to be formed by the alisphenoid bone and the latter by the orbitosphenoid. The fissure is also traversed by the ophthalmic vein as it passes from the orbit into the cavernous sinus. The sphenoidal fissure thus corresponds in every detail, excepting in that it transmits the ophthalmicus trigemini, to the orbital opening of the myodome of Amia. But the fissure lies, in man, between the alisphenoid and orbitosphenoid bones, instead of between the parasphenoid and basisphenoid legs of the alisphenoid. This however seems unimportant, for, as I have also pointed out ('97b), the so-called basisphenoid of Amia is probably simply a part of the orbitosphenoid, ossifying from a separate and independent center; the orbitosphenoid of Amia and Man invading a region that is ossified as part of the alisphenoid in teleosts. Regarding the ophthalmicus trigemini, which traverses the sphenoidal fissure in man, that nerve is the homologue of the ophthalmicus profundus of fishes, a nerve not found in Amia or teleosts, but as it arises from the profundus ganglion it would probably issue from the skull with the ciliaris profundi, which latter nerve traverses the orbital opening of the myodome.

The foramen rotundum and the foramen ovale both perforate, in man, the great wing of the sphenoid, and transmit respectively the superior and inferior maxillary branches of the trigeminus,

the latter nerve being accompanied by certain meningeal vessels. The foramen rotundum is said by Thane (Quain, vol. II, pt. I) to have been separated off from the sphenoidal fissure by the growth of bone around the nerve, the foramen ovale being similarly cut off from the foramen lacerum. The foramen lacerum is an aperture between the apex of the petrous portion of the temporal bone and the body and great wing of the sphenoid, and would seem to correspond to the trigeminus foramen of Amia, though it may include some part also of the trigeminus opening of the trigemino-facialis chamber of teleosts. Comparison with fishes would thus indicate that the foramen ovale and the foramen rotundum must both be parts of the foramen lacerum, instead of being respectively parts of that foramen and of the sphenoidal fissure. The foramen spinosum of man, which perforates the great wing of the sphenoid and transmits the large middle meningeal vessels, must have its homologue in one or both of those perforations of the alisphenoid that, in teleosts, transmits branches of the external carotid artery and orbito-nasal vein.

The foramina related to the nervus facialis are not so readily homologized. The facialis foramen and the facialis opening of the trigemino-facialis chamber of teleosts must together represent parts of the Aqueduct of Fallopius of man, but apparently not the whole of it, for the lower part of the aqueduct is said by Thane to be included between the outer surface of the periotic and the tympanic plate, and until this latter plate is identified in fishes, the homologue of the stylo-mastoid foramen can not be determined. The hiatus Fallopii, which leads from the Aqueduct of Fallopius to the depression on the petrous that lodges the Gasserian ganglion, is evidently that part of the trigemino-facialis chamber that lies between the facialis and trigeminus foramina; the Vidian canal being what I have described as the palatine canal in Amia, a canal that lies between the parasphenoid (pterygoid of man, Gaupp, '05) and the cartilaginous basis cranii of that fish. In teleosts this canal is absent because of the suppression of the cartilage in this region. The internal jugular vein does not, in man, issue with the nervus facialis, issuing instead through the jugular foramen which transmits also the glossopharyngeus, vagus and spinal accessory nerves. The internal carotid canal, which, in man, traverses the petrous part of the temporal bone, seems not to be the exact homologue of the internal carotid foramen of fishes, this latter foramen lying between the proötic and parasphenoid instead of traversing the former bone. But as the artery then traverses the cavernous sinus in man and the myodome in fishes the canal of the one must be in large part the homologue of the foramen of the other.

Regarding the bones of the region, the posterior clinoid wall is represented in the mesial processes of the proötics of Amia, the anterior clinoid wall being represented either by the basisphenoid of teleosts, by the prepituitary part of the mesial processes of the proötics, or by those bones fused to form a single element. The spicula of bone that, in man, sometimes unite the anterior and posterior clinoid processes are then those parts of the mesial processes of the proötics of teleosts that lie lateral to the pituitary opening. The parasphenoid leg of the alisphenoid of teleosts is the great wing of the sphenoid bone of man, the basisphenoid leg of the bone of fishes apparently being suppressed by an invading growth of the orbitosphenoid which forms the small wing of the sphenoid of man. The basisphenoid of fishes, if it persists as a separate bone, is the presphenoid of man, but, as just above stated, that bone of man would seem to at least include the prepituitary parts of the mesial processes of the proötics of teleosts. The basisphenoid of man, if it is found in fishes, would seem to be represented in a part of the proötic, but it is perhaps possible that the median ossification in the dorsal surface of the proötic bridge of my one specimen of Gadus morrhua, described below, may be the homologue of that bone.

Swinnerton, it should here be stated, has arrived, in a study of the development of Gasterosteus, at conclusions quite different from those just above proposed, in so far as regards the position of the myodome relative to the cranial walls in fishes, and the homologies of the hypophysial fenestra. According to him ('02, p. 527) those parts of the parachordals that, in embryos of Gasterosteus, bound laterally the interparachordal fossa, become depressed in late embryonic stages, so as to appear as mere downward processes of the proötics. These processes are said to be capped with cartilage, to each be continued posteriorly by a ridge on the ventral surface of the posterior portion of the related proötic, and, posterior to that bone, by a similar ridge on the ventral surface of the basioccipital. The two processes are said to enclose between themselves the anterior portion of the myodome, which portion is said to accordingly be an actual derivative of the cranial cavity; while the two ridges that form posterior continuations of the processes enclose a posterior portion of the myodome, which is said to be extracranial in position. These conclusions lead Swinnerton to the further conclusion (l. c., p. 528) that the so-called hypophysial fenestra of the skull of adult teleosts is related to the parachordals, alone, and hence can not be the homologue of the pituitary (hypophysial) fossa of embryos, which fossa is related to the hind ends of the trabeculae. The so-called hypophysial fenestra of the adult fish can not then be the homologue of the hypophysial (pituitary) fenestra of higher animals, and Swinnerton accordingly proposes for this fenestra of the adult teleost the name interparachordal fossa. The position, in the adult, of the pituitary fossa of embryos, Swinnerton does not give; the inference being that it has wholly disappeared in that suppression of the hind ends of the trabeculae that is said to take place in late embryonic stages.[1])

Those teleosts in which the myodome is said to be absent can now be considered. Vrolik ('73) says that it is absent in all the Gadidae, and also in Silurus, Lophius and the eel; Gill says ('91b, p. 363) that it is absent in the Cyclopteroidea, and also ('82) in Echeneis; Swinnerton ('02, p. 576) says that it is absent in Fistularia and Syngnathus; and Jordan and Evermann ('98) say that the basis cranii is simple in the Hemibranchii and Lophobranchii, which include Fistularia and Syngnathus; Cope (quoted by Gill, '88, p. 576) says that it is absent in all the fishes of the group Scyphobranchii, which group (Cope, '71) includes the Uranoscopidae, Gobiidae, Blenniidae, Gobiesocidae and Cottidae; Gierse ('04) says that it is wholly wanting in Cyclothone; and Starks ('05 a) says that it is absent in Caularchus, Callionymus and the Batrachididae, confirming also its absence in the Gobiesocidae. McMurrich ('84) says that it is rudimentary in Ameiurus; and Sagemehl ('91, p. 574) says that it has undergone retrogression in Cobitis, Misgurnus, Nemachilus and Acanthophthalmus. Boulenger ('04) says that the basis cranii is simple in the Mormyridae, Osteoglossidae, Pantodontidae, Phractolaemidae, Stomiatidae, Gonorhynchidae, Cromeriidae, Galaxiidae, Gobiiformes, Discocephali, Comephoriidae, Rhamphocottidae, and in all the five families of his suborder Pediculati. He further says that the basis cranii is double in the symmetrical forms of his division I of the suborder Acanthopterygii; which would seem to imply that it is simple in the asymmetrical forms of the same division, that is the Pleuronectidae. And the expression „basis cranii simple", while it is, strictly speaking, descriptive of a condition of the bony skull alone, is currently considered as equivalent to saying

[1]) Gaupp, in Bd. 3 of Hertwig's Handbuch der vergleichenden und experimentellen Entwickelungslehre der Wirbeltiere, a work that I have only seen since this manuscript was sent to press, describes practically similar conditions in Salmo, and arrives at practically similar conclusions regarding the homologies of the parts. This would seem to establish the fact that the basi-occipital portion of the myodome is extracranial in origin. Regarding the prootic portion of the myodome, Gaupp's descriptions would seem to confirm my contention that it is an intramural space and not an intracranial one.

that there is no myodome. The list of fishes said, by one author or another, to be without a myodome is thus large, and I have attempted to control it as far as my material and the literature at my disposal will permit.

In Gadus aeglifinus, Brooks ('84) says that the proötic „unites below with its fellow of the opposite side, and below this with the parasphenoid, the three bones bounding a deep pit, which is open anteriorly, and gives origin to the recti muscles of the orbit". This fish would thus seem to possess a myodome, and as another one of the Gadidae, Gadus merlangus, is easily obtained here, I have examined it in this connection. In this fish there is, as in G. aeglifinus, a deep pit opening into the orbit and giving origin to certain of the recti muscles. The side walls of this pit are formed by the ventral portions of the proötics, those portions of those bones being capped with cartilage and not meeting in the middle line, a hypophysial fenestra, closed ventrally by the underlying parasphenoid, thus being left between them. The dorso-posterior wall, or roof of the pit is thick, and is formed by the proötic bridge, that bridge being formed by the mesial processes of the proötics united by a thick median interspace of cartilage. The cerebral surface of this roof slopes postero-ventrally and forms a convex and triangular-shaped surface between the anterior ends of the large saccular grooves. The wide anterior edge of the roof is bevelled, the bevelled surface sloping antero-ventrally. The transverse edge that lies between this sloping, bevelled surface and the posterior portion of the roof of the pit is continued dorsally, on either side, to form the anterior boundary of the labyrinth recess. The bevelled surface gives attachment to the ventro-posterior edge of a thick tough membrane that fills the large orbital opening of the brain case, a large pocket in this membrane, immediately anterior to the proötic bridge, lodging the pituitary body. In the anterior edge of the proötic there is, as in G. aeglifinus, a deep incisure for the exit of the trigemino-facialis nerves, and from this incisure a groove leads ventro-mesially into the anterior end of the myodomic pit. There is no closed foramen whatever in this part of the proötic bone, all of the nerves that pierce the bone in Scorpaena here passing across its anterior edge. There is also no internal carotid foramen between the proötic and parasphenoid, the internal carotid here passing inward across the anterior edge of the expanded, postorbital portion of the parasphenoid; that edge of the parasphenoid lying slightly anterior to the anterior edge of the ventral portion of the proötic. The anterior end of the large saccular groove is separated from the bottom of the trigemino-facialis incisure by only a thin layer of bone. There is no basisphenoid, but there is, as in Cottus, a considerable basisphenoid thickening of the membrane that closes the orbital opening of the brain case. Posterior to this thickened portion of that membrane and partly enclosed in it, in the region of the membranous pituitary fossa, is the transverse commissure of the pituitary veins. There is thus here a normal myodome, but it has been shortened both anteriorly and posteriorly. Posteriorly this shortening is due to a proötic constriction, while anteriorly it is due to the absence of the usual enclosing bones; for it is evident that the anterior portions of the bodies of the proötics of Scorpaena, and the entire ascending processes of the parasphenoid of that fish, are absent in Gadus.

In a prepared skull that I have of Gadus morrhua, the conditions are all similar to those just described for Gadus merlangus, excepting that there is a median ossicle on the cerebral surface of the cartilage of the proötic bridge, not found in G. merlangus. This ossicle is transverse in position and extends from proötic to proötic along the transverse edge that is continuous, on either side, with the anterior wall of the corresponding labyrinth recess. It is a stout ossicle, of perichondrial origin, and has never been described in any fish so far as I can find.

One further condition of the Gadoid skull needs to be mentioned. The hypophysial fenestra is continued posteriorly, along the ventral surface of the interproötic cartilage, by a relatively deep groove which is prolonged posteriorly by two short recesses in the anterior end of the basioccipital, the two recesses being separated by a thin, vertical, median wall of bone. Laterally, on either side, this groove is in wide communication with a large and deep recess in the proötic. This recess extends antero-dorsally in the bone, lying immediately mesial to the saccular groove and tapering toward its dorso-anterior end, which end lies slightly postero-mesial to the trigemino-facialis incisure. The bone that forms the outer wall of the recess is thin, and seems to be of purely perichondrial origin. In the specimens of Gadus merlangus that were particularly examined in this connection, and which were all fresh specimens that had been slightly boiled, this recess was filled with loose and apparently fatty tissue: but in the skull that I have of Gadus morrhua, which had not been boiled, the recess lodged the spreading lateral portions of a membrane that covered the ventral surfaces of the proötics and the interproötic cartilage, lying between those structures and the underlying parasphenoid. The recess is certainly the homologue of the proötic vacuity found in the proötic of the 45 mm Scorpaena, as stated when describing that fish.

In Uranoscopus scaber the interorbital wall is thick, and is deeply and widely excavated, on its dorso-anterior edge, by the large rostral depression. The central portion of the floor of this depression is formed by the subcircular mesethmoid, the ventral surface of which bone rests directly upon the underlying parasphenoid and, perhaps, also on the vomer; but the existence of this latter contact was not established. The anterior portions of the side walls of the depression are formed by the deeply excavated ectethmoids, the posterior halves of the same walls, and the hind wall, being formed by a specially developed flange of the frontal of either side. No alisphenoid is evident as a separate bone, but it would seem to be represented in, or at least to be replaced by, what appears as an anterior process of the sphenotic. With a ventral process of this alisphenoid part of the sphenotic, and also with an adjoining portion of the anterior edge of the proötic, the ascending process of the parasphenoid is in contact. Posterior to this ventral process, the truncus maxillo-mandibularis trigemini, undoubtedly accompanied by the buccalis lateralis, issues through a perforation of the side wall of a well-developed trigemino-facialis chamber. The ramus ophthalmicus superficialis issues from the same chamber through a foramen that lies between the suturating edges of the parasphenoid and the ventral process of the alisphenoid portion of the sphenotic. This ventral process is, accordingly, a well developed parasphenoid leg of the alisphenoid process of the sphenotic.

Between the parasphenoid leg of the alisphenoid process and the body of that process, dorsally, the parasphenoid posteriorly and ventrally, and the rostral flange of the frontal and the cartilage covering the ventral part of that flange, anteriorly, there is a large subcircular opening. This opening gives exit to the olfactorius, opticus, oculomotorius and trochlearis nerves, and gives entrance to certain of the muscles of the eye, how many or which of them was not determined. The opening is accordingly, in function, an olfactorio-opticus fenestra and an orbital opening of the myodome combined. On the internal surface of the proötic, at a certain distance posterior to the hind edge of this opening, there is a low transverse and nearly vertical flange which suturates in the middle line with its fellow of the opposite side. That part of the cranial cavity of the prepared skull that lies anterior to this transverse vertical flange forms a recess in the cranial floor, but belongs properly to the orbit and not to the cranial cavity. The canal for the internal carotid passes inward between the proötic and the hind edge of the ascending process of the parasphenoid, and opens on the floor

of the recess. The membranes closing this recess toward the cranial cavity were not investigated, but the recess is certainly a myodomic recess, similar to, and as well developed as, that recess in Gadus. Uranoscopus thus has a myodome of the kind found in Gadus. It furthermore has a proötic vacuity larger even than the vacuity in Gadus, and which, as in Gadus, extends posteriorly into the anterior end of the basioccipital.

In Blennius gattorugine the posterior portion of the ventral edge of the proötic is thick and grooved, the mesial edge of this groove representing the mesial process of the bone, and the other edge representing the ventral portion of the body of the bone. Anterior to the groove the actual ventral edge of the bone is formed by the mesial edge of its mesial process. This edge of the bone, as also both edges of the posterior, grooved portion, are widely separated from the corresponding portions of the bone of the opposite side, the space between the mesial processes being bridged by a membrane which underlies the hypoaria and pituitary body. Anteriorly, this membrane is attached to the hind edge of the basisphenoid, that bone being, in this fish, unusually wide in an antero-posterior direction. Beneath this membrane and the basisphenoid, between them and the underlying parasphenoid, there is a long and relatively large space which lodges certain of the eye muscles and is accordingly a well developed and perfectly normal myodome. The pituitary opening and the hypophysial fenestra are simply unusually large, and the pituitary opening lies much further posteriorly than in Scomber and Scorpaena.

In Lophius piscatorius there is, in the prepared skull, no myodome, as Vrolik has stated. In the fresh skull, however, there is a pocket between the bony floor of the skull and an overlying membrane, and in this pocket certain of the eye-muscles have their origin. The pocket is accordingly a myodome. The overlying membrane is thick and strong, and forms the hind wall of the orbit as well as the roof of the myodome. Laterally, on either side, it extends upward and forms, as in Amia, the mesial wall of the trigemino-facialis chamber. The membrane is thus similar to that in Amia, but it is even more extensive than in that fish, for it entirely replaces, in Lophius, the bony mesial processes of the proötics.

In both Syngnathus and Hippocampus, which I have examined in serial sections, there is a large myodome, roofed, in Syngnathus, entirely by membrane, while in Hippocampus the recti externi extend backward beyond the other muscles and pass beneath the cranial floor, between it and the parasphenoid.

In Gymnarchus, of the Mormyridae, a dilapidated skull of which I have, there is apparently no myodome, the conditions here being similar to those found in Ameiurus, which will be later described; but in two other members of the family, Mormyrops deliciosus and Petrocephalus bane, Ridewood ('04b) says there is a myodome.

In Osteoglossum Leichardti and Heterotis niloticus, of the Osteoglossidae, Ridewood ('05a) says there is a myodome; as there also is, according to the same author, in Pantodon Buchholzi and Phractolaemus Ansorgii.

In Galaxias of the Galaxiidae, Swinnerton ('03) says there is a myodome.

In Pleuronectes platessa, Cole & Johnston ('01, p. 13) say there is a myodome.

In Echeneis, of Boulanger's Discocephali, I find, ventro-antero-mesial to the trigemino-facialis chamber, a large aperture, which, in the prepared skull, leads directly into the cranial cavity, along its floor. The aperture is bounded dorso-mesially by a bone that must be the basisphenoid, although the sutures in this region can not be distinguished in my one specimen; and from the hind edge of this bone a strong membrane extends, in the recent state, backward and downward and is attached

to the floor of the cranial cavity. Through the aperture and into the space roofed by this membrane, certain of the eye muscles extend, the space thus being a perfectly normal myodome.

Of the Cottidae, said by Cope to be without a myodome, I have described it in the present work, well developed, in Cottus octodecimospinosus; and Gill ('91b) gives as one of the characteristics of his family Cottoidea, „Myodome more or less developed".

Of the Rhamphocottidae, I have no specimens, but the Cottidae having a myodome, certainly well developed in some species, it must surely be also found in the closely related Rhamphocottidae.

In Gonorhynchus greyi, Ridewood ('05b) says there is a myodome.

Of the entire list of fishes said to be without a myodome, all of the individual species mentioned, excepting only Caularchus, Callionymus, Fistularia, Cyclothone, Silurus and the eel, are thus shown to have that canal; while of the several families in which the canal is said to be absent, some one or more members of each family, or of a closely related subfamily, are also shown to have it, excepting only the Cyclopteroidea, Cromeriidae, Gobiidae, Gobiesocidae, Stomiatidae, Batrachididae and Comephoridae. Of the Cyclopteroidea, Cromeriidae, Gobiesocidae, Stomiatidae, Batrachididae and Comephoridae, I have no specimens; neither have I of Caularchus, Callionymus, Fistularia or Cyclothone. These fishes must accordingly be left out of consideration. Of Fistularia, it may, however, be stated that Swinnerton shows a myodome in Gasterosteus, and that I find a well-developed myodome in Centriscus, both of which fishes belong with Fistularia to the Hemibranchii. Of the Siluridae, Muraenidae, and Gobiidae, I have specimens and they can now be considered.

In Conger conger of the Muraenidae, there is, at the hind end of the orbit, a small median transverse shelf of bone which projects forward slightly above the parasphenoid. The optic nerves leave the cranial cavity along the dorsal surface of this shelf, and beneath it, between it and the parasphenoid, the recti muscles have their origins. The bones of the skull are here all so firmly ankylosed in my specimens that I can not with certainty identify them, but the shelf of bone must certainly be either a basisphenoid, a proötic bridge similar to the bridge of Gadus, or a transverse ridge of the parasphenoid, as in Dactylopterus. And in either case the little space between the bone and the body of the parasphenoid would be a perfectly normal but very much reduced myodome. In a series of sections that I have of a young Conger, the recti muscles all seem to arise from a delicate median membrane, which lies partly beneath and partly anterior to the shelf of bone, each muscle arising directly opposite its fellow of the opposite side; no one of the muscles, apparently, having its origin either on the shelf or on the parasphenoid bone.

In a single small specimen of Gobius cruentatus that I have been able to obtain, the arrangement seems to be exactly similar to that in Dactylopterus. The proötic has a narrow orbital surface which lies at a slight angle to that part of the bone that lies immediately posterior to it and that forms the uniformly thin floor of this part of the cranial cavity. The narrow orbital surfaces of the bones of opposite sides are separated by a wide median interval, and the ventral part of this interval is filled by a transverse ridge on the dorsal surface of the parasphenoid. This ridge on the parasphenoid has the same antero-dorsal inclination as the orbital surfaces of the proötics, and forms the hind wall of a small pocket which lies at the hind end of the orbits, and recalls both the myodomic pocket of Gadus, and the myodome of Dactylopterus.

Of Silurus I can find no description that is of value in this connection. But McMurrich's ('84) descriptions of Ameiurus catus (nebulosus) are of value, and, as I have a few specimens of this fish, it can be described. Short reference must, however, first be made to Sagemehl's descriptions of

the Cyprinidae. According to that author ('91, p. 574), a well developed myodome is found in most of these fishes. In Cobitis, Misgurnus, Nemachilus and Acanthophthalmus, all of which have small eyes, the myodome is said to have undergone retrogression. The weak muscles of the eye are said to all arise in the postero-ventral corner of the orbit, none of them entering the cranial cavity. The anterior edge of the proötic is said to be formed of two lamellae one lying above the other, the dorsal one ending with a free anterior edge, while the ventral one forms the floor of the cranial cavity. The slit-like space between the two lamellae, although it lies considerably posterior to the hind end of the orbit, is said to unquestionably represent a myodome that has undergone reduction. Reference to the figures of Cobitis fossilis (pl. 29, fig. 12) shows that the dorsal lamella must be a rudimentary mesial process of the proötic, and as such Sagemehl doubtless considered it, although he does not definitely describe it as such. Anterior to this process, there is said (l. c., p. 549) to be a wide rhomboidal hypophysial fenestra. The nervus abducens, in those Cyprinidae that are said to have no myodome, and of which Cobitis is one, is said not to perforate the mesial process of the proötic, but to apparently issue by the large optic fenestra. The condition of the myodome is thus here closely similar to that in Lepidosteus; that posterior portion of the canal that I have referred to as the saccular space, existing in a reduced condition, well within the brain case, widely separated from the orbit, and in no direct relation whatever to any of the eye-muscles. This condition is thus the reverse of that found in Dactylopterus, Gobius and Gadus, in which fishes this part of the myodome has been crowded out of the cranial cavity into the orbit.

Ameiurus can now be considered, and of this fish I have one skull, prepared some years ago and partly disarticulated, and a few small alcoholic specimens. Of Ameiurus, Mc Murrich says: „Below the proötics, where they meet in the middle line below, and between them and the anterior portion of the basioccipital above, and the parasphenoid below, is a small cavity. This is the almost aborted rudiment of the canal for the orbital muscles, which is largely developed in many fishes, but absent or rudimentary in Silurus, Ameiurus, Gadus, Lophius etc."

This description of the conditions in Ameiurus is not very satisfactory, and it is not explained, either here or elsewhere in the descriptions, that this so-called rudimentary myodome is widely separated from the orbit and out of all relation to the eye-muscles. Yet such is the case. In the anterior three-fifths, approximately, of its length, the ventral edge of the proötic does not meet its fellow of the opposite side, a wide hypophysial fenestra, closed ventrally by the parasphenoid, being left between the two bones. Posterior to this fenestra, the ventral edges of the proötics meet in the middle line, and the two bones there form, on the floor of the cranial cavity, a prominent transverse bolster which has closely the position of the cross-canal of Lepidosteus; and it is certainly in this bolster that McMurrich found the small cavity that he considered as a rudimentary myodome. In two of my small specimens there was no indication whatever of such a cavity; the bolster there being completely filled with cartilage, but having, on its anterior surface, a slight median depression which doubtless lodged the saccus vasculosus. In one other specimen, there was a median cavity extending under, rather than into the bolster, while in a fourth specimen there was a smaller but similar cavity on one side only of the median line. The pituitary body lies immediately anterior to the bolster, directly above the hypophysial fenestra, and a vein that apparently drains the pituitary region begins here and runs directly forward along the floor of the cranial cavity, soon separating into two parts, one on either side. The venous cross-comissure of Lepidosteus thus here seems replaced by a median vein, this being a variation in detail but not in principle. The eye-muscles all have their

origins ventral to and between the optic and trigemino-facialis foramina, on the outer surface of that median process of the parasphenoid that McMurrich considers as a basisphenoid completely ankylosed with the parasphenoid, but which Sagemehl ('91, p. 575) considers, in Silurus, as a simple process of the parasphenoid; none of the muscles entering the cranial cavity. It may furthermore here be stated that these muscles are said by Workman ('00) to be innervated as they are in Amia, and hence as I have shown them to also be in Lepidosteus (present work), and that Ameiurus is the only teleost in which this manner of innervation has, as yet, been described.

Ameiurus thus presents conditions similar to but even more extreme than those in Lepidosteus, the cross-canal of the latter fish here being a solid bolster, due, quite undoubtedly, to the invading growth of the surrounding cartilage. Yet, the condition in Ameiurus is said (McMurrich) to represent an aborted condition of the teleostean myodome, while that in Lepidosteus is said (Sagemehl) to represent a condition from which that myodome was developed! Wishing to determine which of these two directly opposed assumptions is the correct one, I have consulted the geological record, and, while that record certainly does not give a definite solution, it has suggested what seems to me such a solution; for it has led me to ascribe a totally different motive to the origin of the myodome than that proposed by Sagemehl, which, as is well known, is the simple seeking of a better point of origin by one or more of the muscles of the eyeball.

According to Zittel ('87—'90), whom I have selected because of the convenient tables given, representatives of the families Siluridae and Ginglymodi, in the latter of which the living Lepidostei are placed, are found in the Eocene formations, and no earlier; and in all the living representatives of these two families that have been examined in this connection, there is no functional myodome. Representatives of the family Halecomorphi, in which Amia, with a well developed myodome, is placed, are found considerably earlier, in the Jurassic deposits. Certain other families of the Lepidosteidae occur earlier than any of the Amiadae, the Stylodontidae being found in the Dyas (Permian) deposits; but, as two Jurassic representatives of this latter family, Lepidotus and Dapedius, are said by Woodward ('93) to have a „basicranial canal" — that is a myodome — it is evident that Lepidosteus can not descend from them, if its myodome represents a primary condition.

The earliest teleosts are said by Zittel to be the Hoplopleuridae and Clupeidae, both of which are said to be found in the Triassic, considerably earlier than the families Siluridae and Ginglymodi, and as early, even, as any representatives of the order Lepidosteidae excepting only the Stylodontidae. Of these two families of teleosts the Hoplopleuridae are extinct, while the Clupeidae are well represented by living species, several of which, Clupea, Elops, Albula and Megalops, are known to have a well-developed myodome. In Clupea harengus, which I have examined for this purpose, the proötic bridge is thick and has a bevelled anterior edge which slopes antero-ventrally, the whole bridge much resembling that of Gadus excepting that it lies in a horizontal instead of a strongly inclined position.

Several other families of teleosts existed at the beginning of the Cretaceous period, and hence earlier than the Ginglymodi and Siluridae. These families are the Saurocephalidae (extinct), Stratodontidae (extinct), Salmonidae and Scopelidae, all placed by Zittel in his order Physostomi; the Labridae and Chromidae of his order Pharyngognathi; and the Berycidae, Sparidae, Xiphiidae, Carangidae, Cataphracti, Gobiidae and Aulostomi of his order Acanthopteri. In living representatives of these several families, Parker shows a myodome in Salmo salar, of the Salmonidae; in Dactylopterus and Peristedion, of the living Cataphracti, I have described it in the present work: in Gobius of the Gobiidae, a myodome similar to that in Dactylopterus is found, as also already

described in the present work: in Scopelus of the Scopelidae, Supino ('01, 02) shows a large myodome, and I find one in Saurus griseus of the same family: in Crenilabrus pavo, of the Labridae, and in Trachurus trachurus, of the Carangidae, I find a myodome well and normally developed: in Hoplostethus, of the Berycidae, Supino ('04) shows a normal myodome, and Starks ('04, p. 602) gives, as one of the characteristics of the Berycoidea, „Myodome large in front, closed abruptly behind, or open to the exterior posteriorly only through a pore": in Fistularia, of the Aulostomi, it is said by Swinnerton not to be developed, but, as already stated, this may be incorrect: in a Mediterranean Sargus, and in Chrysophrys aurata, both of the Sparidae, I find a well developed myodome; as I also do in a Mediterranean Xiphias of the Xiphiidae.

It is thus seen that a myodome is found in certain living representatives of nearly all of the earliest known families of teleosts; and that certain of these families, certain of the living representatives of which possess a myodome, are found in earlier geological periods than any of the families of the Teleostei the living representatives of which are known not to possess it. Certain of the Stylodontidae, the earliest known representatives of the Lepidosteidae, are also said to possess a myodome. The palaeontological record, as given by Zittel, thus certainly indicates that the conditions from which the myodome is developed are not to be looked for in either Lepidosteus or Silurus, but in fishes belonging to earlier deposits than those in which those teleosts and ganoids that possess a myodome are found; and the only fishes so found, living representatives of which are known, are, in Zittel's terminology, the Selachii, Dipnoi, Chondrostei, and Crossopterygii.

In the Selachii, Gegenbaur ('72) shows a thick interorbital wall, and a pituitary fossa (Sattelgrube) which lies between, or but little posterior to, the posterior portions of the orbits. The canalis transversus, which transmits the pituitary vein, lies in or beneath the bottom of this fossa (Hexanchus, Mustelus, Galeus), or but slightly posterior to it (Heptanchus, Scymnus). In Ceratodus (Bing & Burckhardt, '05, P. 523) a similar interorbital wall and pituitary fossa are found; and the same is true of Acipenser (Parker, '82a). In Polypterus there is a thick interorbital wall, and Pollard ('92) shows, in the cranial cavity of this fish, a cartilaginous shelf which, as already stated, closely resembles the proötic bridge of Amia. Bing & Burckhardt ('05, p. 571) show this bridge much more inclined than Pollard shows it, and they show, as Pollard does, what is probably the saccus vasculosus, projecting backward beneath the bridge. No mention is made, in either Ceratodus, Acipenser or Polypterus, of a canalis transversus or pituitary vein, but this vein must certainly exist in each of these fishes, and must lead into the orbit of either side, as it does in the Selachii and Teleostei. Imagine the orbits, in either one of these several fishes, to be enlarged and deepened. This would necessarily shorten the canal traversed by the pituitary vein, and would, if sufficiently continued, bring the pituitary fossa into the hind ends of the orbits, much as it is actually found in Dactylopterus and Gadus. Certain of the eye-muscles would then almost necessarily have their points of origin transferred to this pituitary pocket, and a myodome would be established.

This being accepted as the manner of origin of the myodome, do Lepidosteus and the Siluridae present a primary or a secondary condition? It is evident that they might be considered as presenting either one or the other, but it seems to me that both of them present a primary condition, for, as already stated, if the anterior edge of the proötic bridge of Polypterus were to be bent downward until it touched and coalesced, everywhere excepting in the middle line, with the underlying floor of the cranial cavity, it would give rise to a condition closely resembling that found in Lepidosteus: and if the cross-canal, thus produced, were to be invaded by the surrounding cartilage until only

a slight pit was left on its anterior surface, it would give rise to the conditions found in Ameiurus. Under this assumption the condition of the myodomic region, as it exists, both in Lepidosteus and Ameiurus, would be primary and not derived secondarily from a pre-existing myodome. But this presupposes, if Ameiurus can be considered as typical of the Siluridae, either that the Weberian apparatus has been developed independently in the Siluridae and the other families of the Ostariophysi, or that the myodome has been developed, in those families of the Ostariophysi in which it is found, wholly independently of its development in other teleosts. For that a myodome could have been developed from the condition found in Ameiurus seems most improbable, Ameiurus quite certainly representing the end of a line in which the saccular portion of the myodomic region is aborting, whether it be primarily or secondarily.

Still another suggestion regarding the myodome is that its basioccipital extension may have been developed in relation to a vertebral depression on the anterior surface of that bone. In Trigla lyra, I have shown that, that depression in the anterior end of the basioccipital that lodges the posterior portion of the myodome is lined with a layer of dense bone that is similar to the bone that lines the vertebral depression in the hind end of the same bone, and that these two linings of dense bone are connected by a small median line of similar bone. This suggests, as I have already stated, that the myodomic depression on the anterior end of the basioccipital of this fish is, like the depression on its hind end, a vertebral depression, and if this be true of this fish, it must also be true of all other fishes in which the myodome has a basioccipital extension. In Gadus and Saurus the myodome has no basioccipital extension, but in both these fishes there is, nevertheless, a depression on the anterior end of the basioccipital, and this depression — although lodging no part of the myodome — would certainly seem to be the homologue of the myodomic depression of other fishes. This depression, in Gadus and Saurus, is continuous with a large vacuity in the hind edge of the prootic, and if the one is a vertebral depression on the anterior end of the basioccipital the suggestion is evident that the other might be a depression in some way related to a similar depression on the hind end of the proötic. The proötic vacuity both of Gadus and of Saurus is in communication, by the intermediation of the hypophysial fenestra, with the myodomic pocket on the anterior surface of the proötic. The supposition is thus evident that a myodomic pocket might have been first developed in relation to a vertebral depression on the anterior surface of the proötic region, and that this depression, pushing backward and gradually obliterating or absorbing a similar depression on the posterior surface of the same region, and then even occupying also a vertebral depression on the anterior end of the basioccipital, has given rise to all known forms of the myodome. But this necessarily attributes a vertebral origin to the basioccipital and proötic, for which, in the case of the proötic, there is no apparent warrant. Furthermore, according to Swinnerton's descriptions of the development of the basioccipital in Gasterosteus, even the depression in the anterior end of that bone can not be a vertebral one. For that author says ('02, p. 524) that, in that fish, a crest of membrane bone grows downward, in the middle line, from the ventral surface of the primary portion of the basioccipital, and that „within the substance of the fore part of this crest is a cavity which opens in front and receives the hinder end of the external rectus muscle; this is the homologue of the anterior conical excavation of the basioccipital of the Pike and many other teleosts".

Summary.

1. The mesethmoid processes of fishes are processes of the mesethmoid bone, or of the ethmoid cartilage, that give origin to the ethmo-maxillary ligament, and that support or give attachment to the hind end of the nasal of either side. In the Loricati they are prominent processes of the mesethmoid; in Trigla and Peristedion they are small processes of the same bone, wholly concealed beneath the nasals; while in Dactylopterus they are small processes of the ethmoid cartilage.

2. The dilatator, temporal and supratemporal fossae of fishes are grooves on the dorsal surface of the primary cranium, more or less completely roofed by dermal bones. Each of these grooves may have an anterior extension that lies upon the outer surface of the dermal bones of the roof of the skull, as in Scomber. In the mail-cheeked fishes, these anterior extensions are not found, but the areas occupied by them in Scomber are represented, on either side of the dorsal surface of the skull of the Loricati, by contiguous regions bounded by four more or less developed ridges that radiate approximately from the frontal spine. The ridge between the anterior extensions of the temporal and supratemporal fossae is in a measure continuous with the epiotic ridge on the posterior surface of the skull, and the posterior semicircular canal lies internal to this latter ridge. The ridge between the anterior extensions of the temporal and dilatator fossae is similarly continuous with the ridge that forms the boundary between the posterior and lateral surfaces of the skull, and the posterior leg of the external semicircular canal lies internal to a portion of this ridge. The ridge forming the anterior boundary of the anterior extension of the dilatator fossa is approximately continuous with the ridge that separates the hind wall of the orbit from the lateral surface of the brain case, and the summit of the anterior semicircular canal lies in a measure internal to it. The position of the frontal spine, from which these several ridges radiate, corresponds somewhat to that of the opening of the endolymphatic tube in selachians. The subtemporal fossa, on the lateral surface of the skull, lies between the external semicircular canal and the utriculus.

The temporal fossa may have an epiotic diverticulum, and it may also have, as in Amia, an anterior diverticulum. This latter diverticulum lies on the dorsal surface of the primary cranium, beneath the dermal bones of the roof of the skull, and in certain fishes (Elops, Albula) it becomes a large and important portion of the fossa. But this anterior diverticulum of the fossa is not to be confounded with the anterior extension just above referred to, the former lying ventral and the latter dorsal to the dermal bones.

The anterior extensions of the supratemporal grooves have coalesced in the Loricati to form the subquadrangular groove on the vertex.

3. The premaxillary of the mail-cheeked fishes has, on its anterior end, two processes, one of which is the ascending process properly so-called, and the other an articular process; but the two processes together are usually referred to as the ascending process of the bone.

The articular process is probably the earlier acquisition of the two, is apparently found in all osseous fishes, and it, alone, is sometimes miscalled the ascending process of the bone (Amia, Salmo).

The ascending process is formed by the fusion with the premaxillary of a supraethmoid bone, the latter bone being primarily developed in protective relation to a line of latero-sensory organs, and being so found, not only in certain ganoids (Amia, Polypterus) but also in Elops and probably

in Belone, these two teleosts being the only ones in which it is known to occur. In Belone the bone is indistinguishably fused with the premaxillary, while in Elops it is found as an independent ossicle.

4. The maxillary of the mail-cheeked fishes has, on its anterior end, a process that may be called its ascending process. This process gives articulation to the articular process of the premaxillary, and itself articulates, by the intermediation of a pad of semi-cartilaginous tissue, with the dorsal surface of the ascending process of the vomer. This process of the maxillary is apparently found in all the Acanthopterygii and Anacanthini of Günther's classification, but it is not evident in all descriptions of the Physostomi. In those fishes in which it is found it varies greatly in its development, and may even be found as two instead of as a single process.

5. The vomer of fishes is primarily a bone, doubtless paired, that is developed in relation to tooth-bearing plates on the dorsal surface of the mouth cavity; and it was primarily limited to the roof of that cavity. In certain teleosts, however, this tooth-bearing plate has acquired a dorsal limb which may be said to consist of a head and two ascending processes, one on either side; and these ascending processes are quite certainly formed by the fusion, with the tooth-bearing plate, of the pre-ethmoid (septomaxillary, Amia) bone of either side. When the pre-ethmoids are found as independent ossifications the vomer is without ascending processes. The ascending process of either side gives articulation to the ascending process of the corresponding maxillary.

6. The septomaxillary of the Amphibia and the higher vertebrates is probably represented in fishes by the antorbital bone of Amia, that bone being developed in protective relation to the infranasal portion of the latero-sensory canals. This antorbital, latero-sensory bone is found in Polypterus and Elops, as well as in Amia, and is possibly also found in certain of the Siluridae (Pollard). In Polypterus it fuses with the premaxillary to form an infranasal process of that bone.

7. In Macrodon there is a bone, called by Sagemehl the accessory palatine, that is apparently developed in the maxillary breathing valve of the fish, and that is accordingly the homologue of the so-called vomer of Polypterus. It has never been recognised in any other teleost.

8. The palato-quadrate articulations with the ethmoid region of the skull differ considerably in different ones of the mail-cheeked fishes examined. In Scorpaena and Sebastes there are two of these articulations, one with an anterior palatine process of the ethmoid cartilage and the other with the ectethmoid; the lachrymal also articulating with the latter bone. In Cottus the articulation with the ectethmoid is suppressed, the palatine there being bound to the lachrymal and that bone alone articulating with the ectethmoid. In Trigla, this posterior articulation, with the ectethmoid, is much as in Cottus, while the anterior articulation, with the ethmoid cartilage, has been largely replaced by a swinging articulation (or attachment) of the lachrymal and palatine with the antero-lateral corner of the nasal bone. In Dactylopterus this latter articulation is still more pronounced.

9. The quadrate has, in most if not in all teleosts, a posterior process which forms the posterior boundary of the symplectic groove on the internal surface of the bone and has supporting relations with the preopercular. This process of the quadrate is not found, as a part of that bone, in the bony ganoids, but it is elsewhere represented both in Amia and Lepidosteus. In Amia it has fused with the symplectic to form a process of that bone that gives a supplementary articulation to the mandible; while in Lepidosteus it is the independent, so-called preoperculum of Parker's descriptions (interoperculum, Collinge), which, in that fish, has an independent articulation with the quadrate. In the Muraenidae, the process and the symplectic seem to both be indistinguishably fused with the body of the quadrate.

The so-called quadrates of osseous fishes are thus not all equivalent structures. The articulations of the mandible with the suspensorial apparatus are also not all similar; Amia being the one known exception to the otherwise general rule, but Lepidosteus somewhat resembling it. A further development of the conditions found in Amia might transfer the mandibular articulation from the palato-quadrate to the hyomandibular.

10. On the hind edge of the metapterygoid, in all of the mail-cheeked fishes examined excepting Cottus and Dactylopterus, there are two flanges, apparently of membrane (exosteal) origin, one of which is lateral and the other mesial in position. Between these two flanges the external carotid artery runs downward to fall into the arteria hyoidea shortly before that artery joins the opercular hemibranch, and after it has passed from the external to the internal surface of the palato-quadrate apparatus. On the opposing surfaces of the two flanges the lavator arcus palatini muscle has the larger part of its surface of insertion.

In Cottus and Dactylopterus these two flanges, instead of being one lateral and the other mesial, are respectively one ventral and the other dorsal; both flanges lying in the plane of the body of the metapterygoid, with their adjoining edges fused but perforated by a foramen which transmits the external carotid and represents the V-shaped space between the flanges in the other fishes. In these two fishes the flanges appear to be of endosteal rather than of exosteal origin.

In Amia the lateral one of these two flanges is represented in the so-called metapterygoid process of the metapterygoid, the mesial flange being represented in that part of the body of the metapterygoid that lies posterior to the process. In Amia both these parts of the bone are quite evidently of endosteal origin.

11. In all of the mail-cheeked fishes examined there is a vessel, apparently an artery, that arises in connection with what seem to be either glomuses or rudimentary glandular structures related to the efferent arteries of the first three branchial arches. Certain evident connections of these glomuses with the lymphatic vessels were found, and occasional apparent connections with the arteries, but no indication whatever of a connection with the venous system. The vessel parallels the common carotid and its branches, and peripherally the walls of the branches of the vessel change abruptly in character, and there appear as lymphatic spaces. The fact that the external carotid branch of the vessel traverses the trigemino-facialis chamber in much the position of the hyo-opercularis artery of Amia, led me at first to homologize the vessel with that artery, but as there is much doubt of the correctness of this homologization I have described the vessel as the vessel x. In Dactylopterus one branch of the vessel seemed to enter the opercular hemibranch. In Polyodon the system is much more developed than in the mail-cheeked fishes, and I am investigating it in that fish. It would seem as if the glomuses from which the vessel arises might be serial homologues of certain of the nephritic structures, and possibly also homologues of the so-called thymus of Polypterus.

12. The external carotid, in all the fishes examined, traverses the trigemino-facialis chamber, gives off several branches, and then terminates in a branch which turns downward between two flanges on the hind edge of the metapterygoid and falls into the arteria hyoidea shortly before that artery enters the opercular hemibranch. This terminal portion of the external carotid corresponds closely in position to, and is probably the homologue of the secondary afferent pseudobranchial artery of my descriptions of Amia, and its connection with the arteria hyoidea, instead of with the pseudobranch, would give origin to the teleostean arrangement.

13. The alisphenoid is perforated, in Scorpaena, Trigla and Lepidotrigla, by a foramen which transmits delicate branches of the external carotid artery and the vessel x, these branches being accompanied by a nerve which is composed of the lateralis fibers destined to innervate the terminal organ of the supraorbital canal and of certain other general cutaneous or communis fibers. In Dactylopterus, the nerve that traverses the foramen does not contain lateralis fibers; the nerve destined to supply the terminal organ of the supraorbital canal there having an extracranial course. The alisphenoid is also perforated, or notched, in Scorpaena, Trigla and Lepidotrigla by another foramen, which transmits the homologue of the anterior cerebral vein of my descriptions of Amia. These foramina, one or both, are found in the other mail-cheeked fishes also, but the arteries and veins that traverse them were not there traced.

14. The parietal is fused, in all the mail-cheeked fishes examined, with a mesial extrascapular latero-sensory element to form a single bone, which I have called the parieto-extrascapular. This same fusion of these two bones is also found in the Characinidae and Cyprinidae (Allis '04) and has been definitely established in no other fishes that I know of, excepting Chanos.

15. The side walls and floor of the skull of osseous fishes are more or less completely double in the sphenoid (orbito-temporal, Gaupp) and labyrinth regions; these walls being there represented in varying proportions by membrane, cartilage or bone. Between the two walls, in the sphenoid region, lies the myodome with its upper lateral or trigemino-facialis chambers, while between the two walls in the labyrinth region lie the membranous ears. The myodome and its trigemino-facialis chambers are thus all intramural spaces. The floor of the myodome proper is perforated by the hypophysial fenestra, while its roof is perforated by the pituitary opening. These two perforations of the cranial floor are doubtless strictly homologous in all vertebrates, but it must be determined, in each case, which one of the two perforations is in question. The myodome proper lodges a cross-commissure of the pituitary veins, and is the probable homologue of the cavernous and intercavernous sinuses of the human skull. The postpituitary portion of its roof apparently always chondrifies, and is the postclinoid wall. The prepituitary portion of its roof does not usually chondrify (Argyropelecus may be an exception), and it and the basisphenoid, one or both, represent the anterior clinoid wall. The orbital opening of the myodome, on either side, is the sphenoidal fissure.

The trigemino-facialis chamber of either side is, in the mail-cheeked fishes, and probably in most other teleosts, separated from the myodome by a partition of bone. It lodges the trigeminus and related sympathetic ganglia, and is the homologue of the cavum Meckelii of the human skull. Its outer wall is, in all the mail-cheeked fishes examined, excepting Cottus, represented by a narrow bridge of bone, this wall of the chamber here forming the outer surface of the skull. In Cottus this outer wall is entirely of membrane, the inner wall of the chamber thus here forming the outer surface of the prepared skull. The internal wall of the chamber forms part of the bounding walls of a recess on the internal surface of the skull, and this recess lodges the lateralis and communis portions of the V—VII ganglionic complex. In Amia these portions of the ganglionic complex lie in the upper lateral chamber of the myodome. There is accordingly question as to whether the inner wall of the chamber of teleosts corresponds exactly to the same wall in Amia. In any event, the recess that lodges, in teleosts, the lateralis and communis ganglia would seem to be the homologue of some part of the aqueduct of Fallopius.

The trigemino-facialis chamber is continued anteriorly by an intramural space that lodges the jugular vein and the truncus ciliaris profundi. The outer wall of this space is largely of membrane in

all the mail-cheeked fishes examined, excepting Cottus, and there appears as a jugular groove on the outer surface of the prepared skull. In Cottus the outer wall of the space is of bone and the inner wall largely of membrane, the space there appearing as a recess on the inner surface of the prepared skull. The outer wall of the space, primarily of membrane, is invaded to a different extent, in different fishes, by the neighbouring bones, thus giving rise to greatly varying conditions.

16. The myodome of fishes is primarily a subpituitary space that is connected with the orbit of either side, or with the orbital region, by a canal that transmits the pituitary vein. Secondarily this subpituitary space acquires a wide communication with the orbits, the primal cause of this secondarily acquired communication apparently being a deepening of the hind ends of the orbits due to a marked enlargement of the eyeballs. Following this deepening of the orbits, certain of the eye-muscles of either side enter the pituitary canal and, enlarging that canal, finally wholly break down the wall that separates the orbits from the subpituitary space.

It seems possible that the subpituitary space may represent the conical depression on the anterior surface of the body of a vertebra, the later acquired, posterior, or basioccipital extension of the myodome then possibly being due to the assimilation of similar depressions in more posterior vertebrae.

17. The peripheral course of each of the cranial nerves is so constant that it would seem to be of greater value for the determination of the segmental position of the nerve than the apparent centers of origin of the fibers composing the nerve; it seeming more reasonable to postulate varying composition, and condensations of ganglia or of centers of origin, than variations in peripheral course. This being so, a nomenclature based on peripheral course seems much preferable to one based on the character of the component fibers of the nerve or on the apparent centers of origin of those fibers.

18. In all the Loricati examined, the ramus palatinus facialis either perforates the proötic bridge or adjoining portions of the side wall of the proötic, and so passes from the cranial cavity directly into the myodome. In all of the Craniomi examined this nerve first passes from the cranial cavity into the trigemino-facialis chamber and then traverses that chamber to issue by its trigeminus opening and so enter the myodome.

19. In all of the mail-cheeked fishes examined, excepting Dactylopterus, the nervus abducens, in passing from the cranial cavity to the muscle it innervates, either passes over the anterior edge of the postpituitary portion of the proötic bridge or perforates that bridge near its anterior edge. In Dactylopterus the nerve first passes from the cranial cavity into the trigemino-facialis chamber and then issues from that chamber through its trigeminus opening to reach the muscle it innervates. In Lepidosteus also the nerve has this latter course.

20. Cottus differs markedly, in many more or less important anatomical features, from the other Loricati, and Dactylopterus differs still more markedly from the other craniomi; and if craniological characteristics are of any especial value in phylogenetic determinations, it would seem as if these two fishes could not be closely related to the other fishes of the mail-cheeked group.

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Explanation of Figures.

Index letters.

Aap	Adductor arcus palatinus.
Ah	Adductor hyomandibularis.
ah.fr	Foramen for the arteria hyoidea.
ANG	Angular.
Ao	Adductor operculi.
ART	Articular.
art.h	Articular process of the hyomandibular, or corresponding process or facet on the skull.
art.mx.	Articular process of maxillary.
art.pmx	Articular process of premaxillary.
AS	Alisphenoid.
asc.mx.	Ascending process of maxillary.
asc.pmx	ascending process of premaxillary.
asc.v	Ascending process of vomer.
BO	Basioccipital.
BS	Basisphenoid.
cb	Ciliaris brevis.
cl	Ciliaris longus.
D	Dentary.
D.ECP	Dermo-ectopterygoid.
dgr	Dilatator groove.
Do	Dilatator operculi.
ec.fr	External carotid foramen.
ECP	Ectopterygoid.
ECT	Ectethmoid.
ENP	Entopterygoid.
EP	Epiotic (Exoccipitale, Sagemehl, Exoccipital, Allis).
ESC	Extrascapular.
EX	Exoccipital (occipitale laterale, Sagemehl).
fc	Facialis canal through the hyomandibular.
f.fr	Facialis foramen.
fo	Facialis opening of trigemino-facialis chamber.
FR	Frontal.
gc	Ciliary ganglion.
gem	Communis ganglion.
ggle	Extracranial glossopharyngeal ganglion.
ggli	Intracranial glossopharyngeal ganglion.
gl	Nervus glossopharyngeus.
glfr	Glossopharyngeus foramen.
gp	Profundus ganglion.
gt	Trigeminus ganglion.
gsy	Sympathetic ganglion.
gv^e	Extracranial vagus ganglion.
gv^i	Intracranial vagus ganglion.
HMD	Hyomandibular.
ic.fr	Internal carotid foramen.
io^{1-11}	1st. to 11th. Infraorbital latero-sensory organs.
ioc	Infraorbital latero-sensory canal.
IOP	Interopercular.
$IOR^{1—4}$	1st. to 4th. Infraorbital bones.
LA	Lachrymal.
Labe I—V.	Levator arcus branchialis externus of first to fifth branchial arches.
$Labi^a$	Levator arcus branchialis internus, anterior muscle.
$Labi^p$	Levator arcus branchialis externus, posterior muscle.
Lap	Levator arcus palatinus.
Lo	Levator operculi.
mef.fr	Foramen for mandibularis externus facialis.
MET	Mesethmoid.
met.pr.	Mesethmoid process.
mif.fr	Foramen for mandibularis internus facialis.
MP	Metapterygoid.
MX	Maxillary.
mx.p	Maxillary process of Palatine.
NA	Nasal.
na	nasal aperture.
nf	nervus facialis.
nll	Nervus lineae lateralis.
o	Nervus opticus.

oc.fr	Foramen for occipital nerves.
ol	Nervus olfactorius.
ol.fr	Olfactory foramen.
OP	Opercular.
opl	Ophthalmicus lateralis canal.
OPS	Opisthotic.
P	Palatine.
PA.ESC	Parieto-extrascapular.
pf	Palatinus facialis.
pmo^{1-11}	1st. to 11th. Preoperculo-mandibular latero-sensory organs.
PMX	Premaxillary.
PO	Pontinal.
POP	Preopercular.
POR	Postorbital.
pr.fr	Foramen for nervus profundus.
PRO	Proötic.
PS	Parasphenoid.
PSF	Postfrontal.
PT	Pterotic.
Q	Quadrate.
R	Rostral.
r.ctf	Ramus communicans from trigeminus to facialis.
r.int.inf	Branch of oculomotorius to rectus internus and rectus inferior.
rl	Radix longa.
r.oi	Branch of oculomotorius to obliquus inferior.
r.rs	Branch of oculomotorius to rectus superior.
SCL	Supraclavicular.
SO^{1-6}	1st. to 6th. Supraorbital latero-sensory organs.
SO	Supraoccipital.
soc	Supraorbital latero-sensory canal.
SOP	Subopercular.
SOR^1	1st. Suborbital.
SOR^2	2nd. Suborbital.
SPH	Sphenotic.
spoc	Spina occipitalis.
S.POP	Suprapreopercular.
SSC	Suprascapular.
stc	Supratemporal latero-sensory canal.
sto^{1-2}	1st. to 2nd. Supratemporal latero-sensory organs.
SY	Symplectic.
Tda	Transversus dorsalis anterior.
tfc	Trigemino-facialis chamber.
t.fr	Trigeminus foramen.
tgr	Temporal groove.
to	Trigeminus opening of trigemino-facialis chamber.
vfr	Vagus foramen.
VO	Vomer.

Explanation of Plates.

The figures used for illustration were to have been made from the specimens used for the descriptions, but as those specimens had been more or less injured by repeated handling, other specimens were specially prepared for the drawings. The figures will accordingly be found to differ from the descriptions in certain minor details.

Plate I. Scorpaena scrofa.

Fig. 1. Lateral view of the skeleton of the head x $1^1/_4$.
Fig. 2. Dorsal view of the same x $1^1/_4$.
Fig. 3. Dorsal view of the skull with the right nasal bone in place x $1^1/_2$.
Fig. 4. Ventral view of the same x $1^1/_2$.
Fig. 5. Lateral view of the skull x $1^1/_2$.
Fig. 6. Median view of a bisected skull x $1^1/_2$.

Plate II. Scorpaena scrofa.

Fig. 7. Dorsal view of the skull with the dermal bones removed, excepting the right postfrontal and suprascapular x $1^1/_2$.
Fig. 8. Posterior view of the same with right suprascapular in place x $1^1/_2$.
Fig. 9. Orbital view of the brain case x $1^1/_2$.
Fig. 10. Dorsal view of the vomer x $1^1/_2$.
Fig. 11. Lateral view of the left hyomandibulo-palato-quadrate apparatus x $1^1/_2$.

Fig. 12. Median view of the right hyomandibulo-palato-quadrate apparatus with the preopercular attached x 1½.
Fig. 13. Lateral view of the left maxillary x 1½.
Fig. 14. Median view of the head of the right maxillary x 1½.
Fig. 15. Lateral view of the brain case, showing the insertions of the muscles x 1½.
Fig. 16. Lateral view of the left premaxillary x 1½.
Fig. 17. Median view of the head of the right premaxillary x 1½.
Fig. 18. Ventral view of the frontal x 1½.
Fig. 19. Diagrammatic view of the latero-sensory canals x 1.

Plate III. Sebastes dactylopterus and Scorpaena scrofa.

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Fig. 22. Ventral view of the same x 2.
Fig. 23. Posterior view of the same x 2.
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Fig. 25. Median view of the head of the right premaxillary x 2.
Fig. 26. Lateral view of the left maxillary x 2.
Fig. 27. Median view of the head of the right maxillary x 2.
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Fig. 37. Posterior view of the skull x 2.
Fig. 38. Diagrammatic view of the latero-sensory canals x 1½.

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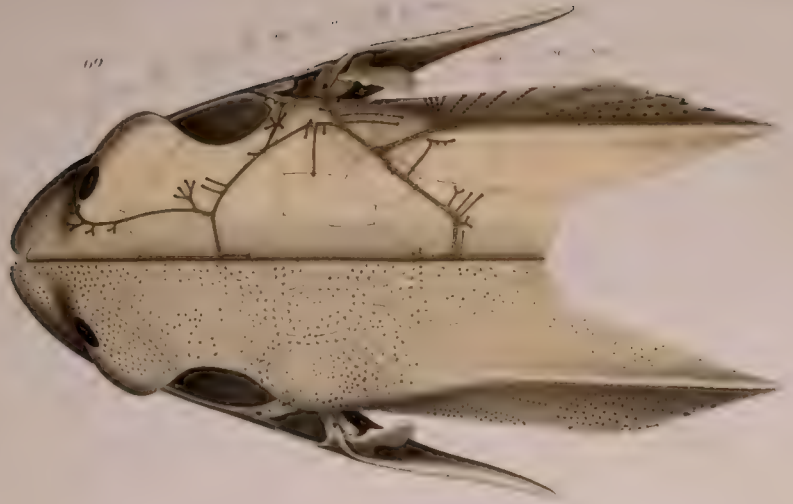

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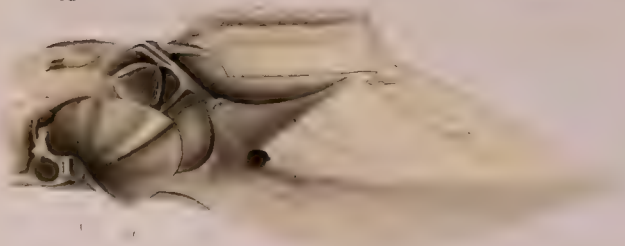

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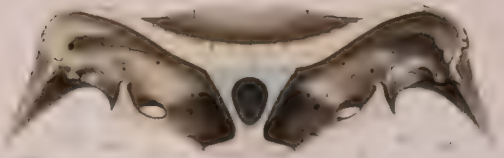

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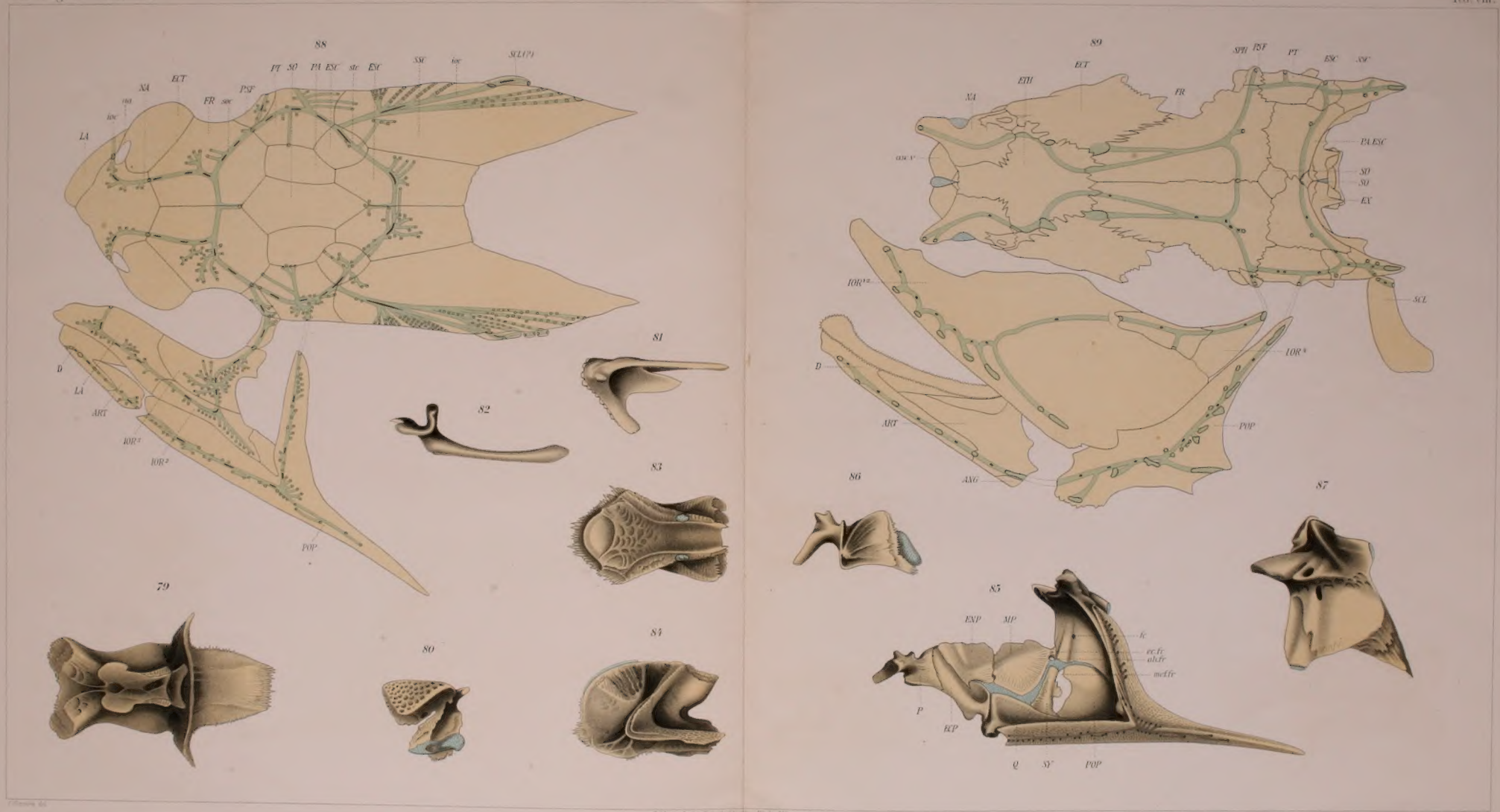
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